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AN INTRODUCTION
TO THE STUDY OF
THE BRACHIOPODA

INTENDED AS
A HAND BOOK

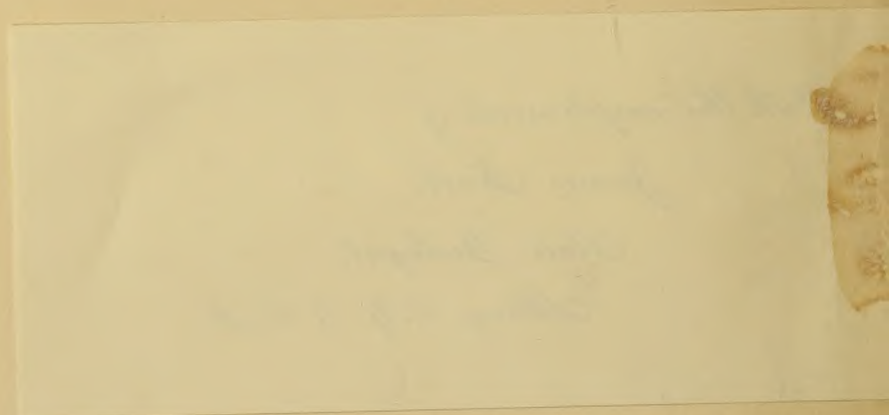
With the compliments of
James Hall,
State Geologist,
Albany, N. Y., U. S. A.

BY
JAMES HALL,
STATE GEOLOGIST AND PALÆONTOLOGIST,

ASSISTED BY
JOHN M. CLARKE.

[From the Report of the State Geologist for 1893.]

ALBANY :
JAMES B. LYON, STATE PRINTER.
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TO THE STUDY OF
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INTENDED AS
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FOR THE
USE OF STUDENTS.

PART II.

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THE GENERA OF THE BRACHIOPODA.

II.

BRACHIOPODA ARTICULATA.

(CONTINUED.)

Spirifer, Sowerby. 1815.

(Plates 23-29.)

Synonyms; *Trigonotreta*, Kœnig, 1825; *Fusella* and *Brachythyris*, McCoy, 1844.

SHELLS transversely elongate, rarely produced axially; with or without median fold and sinus. Hinge-line straight, usually forming the greatest diameter of the shell, but in some of the subdivisions of the genus, short and inconspicuous. Cardinal extremities alate, acuminate or rounded.

Surface covered with granulations, striæ, plications or costa, variously grouped on the lateral slopes and which may be present or absent on the median fold and sinus; these are crossed by concentric growth-lines which may take the form of varices or expanded lamellæ, or be modified into fimbriæ of simple or compound spines. In the subgenera MARTINIA and MARTINIOPSIS the surface is smooth except for the concentric striæ. Shell substance fibrous, generally impunctate; in the smooth species the epidermal layer is minutely pitted.

The pedicle-valve has the umbo more or less elevated over the hinge-line, the apex acute, erect or incurved. The cardinal slopes show a slight tendency to concavity or excavation, and the median portion of the valve is more or less strongly depressed by a sinus. The cardinal area is broad, flat or incurved and its surface is transversely striated; the inner shell-layers bear a series of longitudinal or vertical canals at whose marginal extremities the fibrous tissue is sometimes produced into a row of denticles, corresponding to a row of pits on the opposite valve;

thus forming an accessory articulation of the valves. The essential articulation is effected by means of stout, simple teeth lying at the marginal extremities of the triangular deltidial covering and supported by dental plates which are usually short, but, in rare types, may be produced even to the anterior margin of the valve. The pedicle-passage or delthyrium is usually open. Normally it is closed by a pair of deltidial plates having the form of scalene triangles, which develop from the sides of the delthyrium and meeting, inclose wholly or partially a circular or oval pedicle foramen. At normal maturity these plates become anchylosed along the median suture and form a single convex plate (the so-called *pseudodeltidium*).

The usual absence of the deltidial covering may be due either to accidental removal or to resorption with advancing growth. In the adult and senile stages of development many species, especially in the line of development to *SYRINGOTHYRIS*, form a testaceous callosity in the pedicle-cavity, thickening the umbo and extending across the delthyrium, reaching, in extreme cases, nearly to the cardinal margin.

The muscular area consists of a subtriangular pedicle-impression occupying the pedicle-cavity, and continuous with a deeply impressed oval or obcordate area, which is posteriorly situated and divisible into a narrow median adductors and broad lateral diductors, the surface of the latter being marked by radiating or racemose furrows. The posterior and anterior members of the diductors may frequently be distinguished, the former being of less extent and their surface markings somewhat different from those of the latter.

A median septum in this valve is usually absent, though not infrequently it is in a condition of incipient development, and in certain species having the aspect of *SPIRIFERINA*, it forms a most conspicuous feature of the interior.

In the brachial valve the umbo is inconspicuous; a median fold corresponds to the sinus of the opposite valve. The cardinal area is narrow, and divided by a broadly triangular delthyrium. The dental sockets are narrow, moderately deep and bounded interiorly by highly developed socket walls, the extremities of which support the crural bases.

The cardinal process is a low, transverse, sessile apophysis, having its surface vertically striated; occasionally it is bipartite or it may be wholly resorbed.

The crura are long, straight and slightly divergent; their union with the primary lamellæ of the spiral ribbon is at a broadly obtuse angle. The brachial coils are directed outward and upward toward the cardinal angles of the valves, and their variation in size and direction is in keeping with the differences in the marginal outline of the shell. The number of volutions of the ribbon exceeds that in any other genus of brachiopods. There is no jugum; its position, however, is indicated by a pair of short spinous processes originating on the primary lamellæ soon after their junction with the crura, and which are directed inward with a slight convergence.

The muscular area has about the same extent as that of the pedicle-valve, though less distinctly impressed and generally more elongated. It is constituted of two pairs of adductor impressions with their surfaces radiately or palmately striated. The anterior pair are central, narrow at their posterior extremities which are embraced by the broader posterior scars.

A faint median septum is sometimes present. In some instances of importance the socket walls are supported by septa which may be considerably produced over the bottom of the valve.

In both valves the genital region is distinctly punctated, but vascular markings are rarely observed.

Type, *Anomites striatus*, Martin (1809). Carboniferous limestone.

This comprehensive genus has been divided into the following sections, based largely upon American species, though it is believed that with the addition of some equivalent division the grouping will be found generally applicable to all Spirifers.

Section I. RADIATI. (Plate 23, figs. 1-15.) Typical example, *Spirifer radiatus*, Sowerby (including *S. plicatellus*, Sowerby).

Smooth, radially undulated or plicated; fold and sinus smooth; entire surface covered with fine, filiform, radiating striæ, which may be minutely crenulated or granulose.

These radiate shells may be conveniently subdivided as follows:

1. *Pauciplicati*, or those with few low plications; as *Spirifer radiatus*, Sowerby, *S. Eudora*, Hall, from the Clinton and Niagara faunas, *S. macropleura*, Conrad, from the Lower Helderberg group.

2. *Multiplicati*, or those with numerous plications; as *Spirifer Niagarensis*, Conrad, *S. asperatus*, Ringueberg, of the Niagara group; *S. Tullia*, Hall, of the Hamilton fauna; *S. Belphegor*, Clarke, of the Genesee shales; *S. mesaestrialis*, Hall, of the Chemung group.

3. *Dupliciplicati*; a few Upper Silurian species having strong dichotomous plications and the filamentous surface striæ covered with asperities. Such are *Spirifer nobilis*, Barrande, from the étage E₂, and the Niagara limestone of Illinois and Wisconsin, and *S. Schmidt*, Lindström, from the Gotland limestone.

Section II. LAMELLOSI. (Plate 24, figs. 1-20.) Typical examples, *Spirifer perlamellosus*, Hall, *S. mucronatus*, Conrad.

Radially plicated; surface covered with numerous concentric lamellæ. In Silurian species the fold and sinus are non-plicate; the later forms usually bear a low median depression on the fold accompanied by a corresponding median ridge in the sinus.

The lamellose species are conveniently subdivided into two groups:

1. *Septati*; those having a median septum in the pedicle-valve. The septum lies between the bases of the teeth, but does not come into contact with them as in the genus *CYRTINA*, where the latter are supported by dental lamellæ resting on the bottom of the valve.

This character is found in an incipient condition of development in the Niagara species *Spirifer sulcatus*, Hisinger, and is a more conspicuous feature in subsequent forms, *S. perlamellosus*, of the Lower Helderberg, *S. raricosta*, of the Upper Helderberg, *S. consobrinus*, of the Hamilton group, and *S. mesacostalis*, of the Chemung group. Up to the period of the Upper Devonian, at least in American faunas, the existence of this septum in the pedicle-valve is not accompanied by a punctation of the shell-tissue nor by the union of the processes on the primary lamellæ of the spiral arms.

2. *Aseptati*. Those without a median septum in the pedicle-valve. These species are more abundantly plicated, often much more extended on the hinge than in the septate group. The lamellæ are without radial striations. The *Aseptati* group themselves naturally about two type-forms, the first, (a) *Spirifer mucronatus*, Conrad, an alate, multiplicate shell with a single low plication in the sinus and a corresponding depression on the median fold; the other, (b) *Spirifer submucronatus*, Hall, in which the fold and sinus are not plicate.

Section III. FIMBRIATI. (Plate 25, figs. 1-15.) Typical examples, *Spirifer fimbriatus*, Conrad, *S. lineatus*, Martin, *S. arrectus*, Hall.

Shells with few low plications or none; hinge-line not greatly extended, often shorter than the greatest diameter of the shell; dental lamellæ moderately, sometimes notably developed; a low median septum may exist in the pedicle-valve. Surface covered with concentric rows of fringes or fine spines.

This group is divided into:

1. *Unicispinei* = DELTHYRIS, Dalman, 1828, *sensu stricto*; those species in which the concentric fimbriæ are made up of short, simple, hollow spines. These are the early fimbriate species, the type of structure not extending, so far as now known, beyond the Devonian. The shells are distinguished from the other fimbriate Spirifers by their more extended and more distinctly plicated surface and the prominent, often sharply developed fold and sinus. Their more characteristic representatives in the American Palæozoic are *Spirifer crispus*, Hisinger, and var. *simplex*, Hall, of the Niagara faunas; *S. Vanuxemi*, Hall, of the Tentaculite limestone, *S. Saffordi*, *S. octocostatus*, Hall, of the Lower Helderberg group, *S. arrectus*, *S. tribulis*, Hall, of the Oriskany sandstone and *S. duodenarius*, Hall, of the Corniferous limestone. This is the (a) *S. crispus*-type.

An interesting series of forms which has had a parallel development with the *S. crispus*-type begins with the *S. bicostatus*, Vanuxem, and var. *petilus*, Hall, in the Niagara group, is represented by *S. modestus*, Hall, in the Lower Helderberg group, *S. Canandaiguæ*, from the Hamilton group, and possibly, *S. urbanus*-Calvin, from a corresponding horizon in Iowa, the line terminating in (b) *S. lævis*, Hall, from the lower Portage shales.

2. *Duplicispinei* = RETICULARIA, McCoy, 1844; those species in which the fimbriæ are composed of large, compound, hollow spines, often or always with lateral branches. Each spine is divided medially by a vertical septum, and along this line the spine is depressed exteriorly, giving it a double-barreled appearance; from each lateral margin are given off at regular intervals short spinules at right angles to the main spine. (*S. fimbriatus*, Conrad; *S. subundiferus*, Meek and Worthen; *S. hirtus*, White and Whitfield; *S. lineatus*, Martin.)

Section IV. APERTURATI. (Plate 26, figs. 1-10.) Typical examples, *S. aperturatus*, Schlotheim, *S. disjunctus*, Sowerby *S. striatus*, Martin.

Forms with plications on the fold and sinus.

This may be regarded as the typical group of Spirifers as it includes the type-species, *S. striatus*, Martin. Furthermore it is the most richly represented in species and at the same time is a most compact association, not presenting any substantial variations. Its members are strongly impressed with the typical spiriferoid characters which are maintained throughout its existence, the group terminating abruptly at the close of palæozoic time. In internal structure variations are slight and unimportant. The dental lamellæ are, as a rule, inconsiderably developed, and there is no median septum in either valve.

(a) Disjunctus-type. Forms with well-developed fold and sinus, elongate hinge and elevated cardinal area; lateral plications simple, median plications dichotomous or intercalary.

(*Spirifer arenosus*, Conrad, Oriskany sandstone; *Spirifer unicus*, Hall, Corniferous limestone; *Spirifer Whitneyi*, Hall, Lower upper Devonian; *Spirifer disjunctus*, Sowerby, Chemung group.)

A subordinate division of this section is the

(1) Hungerfordi-type (=CHORISTITES, Fischer de Waldheim, 1825), in which the fold and sinus are low, often obsolescent, the outline suborbicular and the cardinal area compressed laterally and incurved; dental lamellæ prominently developed. This type is represented by *S. Hungerfordi*, Hall, of the lower Upper Devonian.

(b) Striatus-type. Forms having a great number of duplicate lateral plications, well developed, rarely acuminate fold and sinus, and narrow, usually extended cardinal area.

(*S. striatiformis*, Meek, Waverly sandstone; *S. Logani*, Hall, Keokuk group; *S. striatus*, Martin; *S. Marcouï*, Waagen.)

(c) Imbrex-type. Alate, mucronate shells, with narrow cardinal area, fine, simple (very rarely duplicate) lateral plications, the plications on fold and sinus being of about the same size as the rest. The surface is frequently lamellose.

(*S. Newberryi*, Hall, Waverly group; *S. Marionensis*, Shumard, Waverly and Choteau groups; *S. biplicatus*, Hall, Kinderhook group; *S. imbrex*, Hall, Burlington limestone.)

(d) Suborbicularis-type. Forms with suborbicular outline, broad, low and usually simple lateral plications; the median plications are few and indistinct.

(*S. suborbicularis*, Hall, Kinderhook-Keokuk groups; *S. subcardiiformis* Hall, St. Louis group.)

(e) Orestes-type. Shells of small size, moderately extended on the hinge; lateral plications simple and usually few in number; fold and sinus angular and with a few plications, of which the median members are much the strongest. Surface usually ornamented by fine, hair-like, often granulous radiating lines.

(*S. concinnus*, Hall, Lower Helderberg group; *S. Grieri*, Hall, Corniferous limestone; *S. Orestes*, Hall, lower Upper Devonian; *S. Keokuk*, Hall, Keokuk group; *S. opimus*, Hall, Coal measures.)

(f) Divaricatus-type. Species with hinge not extended, low fold and sinus; numerous fine dichotomous lateral plications not differing in size from the median plications, all of which are crossed by fine, closely set concentric lines each bearing a fimbria of short, simple spines.

(*S. divaricatus*, Hall, Upper Helderberg and Hamilton groups.)

Section V. OSTIOLATI. (Plate 27, figs. 1-17.) Typical examples, *Spirifer ostiolatus*, Schlotheim, *S. Oweni*, Hall.

Forms with the median fold and sinus without plications.

(*S. pexatensis*, Meek and Worthen; *S. macrothyris*, Hall, Corniferous limestone; *S. Marcyi*, Hall; *S. audaculus*, Conrad; *S. granulosus*, Conrad; *S. Parryanus*, Hall; *S. asper*, Hall, Hamilton group.)

These species, in the degree of plication of the sides and the development of the muscular scars, closely resemble the members of the foregoing group. As a rule the Ostiolati are stouter shells, shorter on the hinge and more ventricose than the

Aperturati; their surface is frequently ornamented with fine granules or interrupted radiating striæ. The cardinal process is developed as a broad, thin, spreading plate, crossed longitudinally by numerous linear depressions. A feature which appears at times in other groups, but which here possesses the highest significance, is the gradual development of the callosity or transverse plate in the apex of the delthyrium. Originally, and always in the earlier species (*S. perextensus*, Meek and Worthen, *S. macrothyris*, Hall, etc.), an accompaniment of adult or senile growth, it eventually becomes a permanent character existing throughout all the later immature growth-phases of the shell. In its simpler manifestations it is a testaceous deposit extending across the delthyrium from its inner margins; as its size increases it unites the dental lamellæ, fills the rostral cavity of the valve and extends forward along the bottom of the shell between the posterior extremities of the diductor muscular bands. This is its condition as usually seen in the middle Devonian species, *S. granulatus* and *S. audaculus*.

Not infrequently this plate is less thickened and extends downward with a convex outer surface for two-thirds the length of the delthyrium, but this particular form of development occurs less often in the early species.

In all its phases it may be coexistent with the true deltidium, though the latter is rarely retained in growth-stages where the apical callosity is well developed.

Section VI. GLABRATI. (Plate 29, figs. 1-3.) Typical examples, *Spirifer glaber*, Martin, *Martiniopsis inflata*, Waagen.

Forms with the surface smooth and glabrous; fold and sinus faintly developed except at the anterior margins of the valves.

The species embraced in this division have stronger differential characters than are found among the preceding groups. The shells have a very short hinge and low cardinal area, and the subcircular marginal outline causes a noticeable alteration in the form of the spiral arms. These have their bases well forward and are extended obliquely to the rounded cardinal extremities, in their position thus approximating the form assumed by these organs in CYRTIA and CYRTINA; the crura, also, and the primary lamellæ become very long.

The character of the muscular impressions is of greater importance; the broad scars of the diductors in the pedicle-valve are here reduced to very narrow dimensions, are scarcely depressed and frequently not defined, but represented only by a radiate marking of the shell. In the brachial valve the adductor scars are two narrow impressions which widen anteriorly but are not divided transversely. The surface of the shell was covered with very fine concentric lines and the epidermal layer, which is usually effaced, was minutely punctate. Faint lateral plications are sometimes visible.

These differences from the normal type of *SPIRIFER* have led many writers to adopt McCoy's term *MARTINIA* for *S. glaber* and its allies. It is evident, however, that this division of the smooth-shelled species embraces more than one subordinate type of structure; they may be divided into

1. *Aseptati* (= *MARTINIA*, McCoy, 1844). Shells in which dental lamellæ and septa are wanting.

(*S. Maia*, Billings, Corniferous limestone; *S. subumbona*, Hall, Hamilton group; *S. glaber*, Martin, Coal Measures.)

2. *Septati*. Shells in which dental plates or septa are well developed. Two groups of the septate *Glabrati* may be recognized:

(a) *MARTINIOPSIS*, Waagen, 1883. Species with the lamellæ developed in both valves.

(*M. inflata* and *M. subpentagonalis*, Waagen, from the *Productus* limestone of India).

(b) ("Gen. nov.," Tschernyschew, = *MENTZELIA*, Quenstedt, 1871(?)), Type of *Martinia semiplana*, Waagen. Shells with dental lamellæ scarcely developed, but with a prominent median septum in pedicle-valve. *MENTZELIA* was founded upon the *Spirifer medianus* of the Muschelkalk.

Subgenus *Cyrtia*, Dalman. 1828.

(Plate 29, figs. 4-11.)

Shells like *SPIRIFER* but having a high vertical cardinal area and semi-pyramidal contour.

(Type, *C. exprorecta*, Wahlenberg. Silurian-Devonian.)

CYRTIA is the designation of a group, having a meager representation and slight morphological value.

Syringothyris, Winchell. 1893.

(Plate 30, figs. 1-11.)

Shells spiriferoid, usually large, with erect cardinal area and broad, multiplicate lateral slopes. Fold and sinus generally non-plicate. In the pedicle-valve the delthyrium is covered by a convex, imperforate plate, which is frequently absent. The dental lamellæ, more or less strongly developed, rest on the bottom of the valve, and at their anterior extremities are produced about the broad diductor impressions. They are united beneath the deltidium by a transverse plate arising from a testaceous callosity in the apex of the delthyrium. This plate is formed by the deposition of accretions to the margins of the delthyrium, which unite in the median line, the union being marked by a raised line less distinct on the upper than on the under side of the plate. From just within the lateral margins and on the inner side of the plate two processes are given off, which are curled toward each other with some irregularity, not meeting except where coalesced with the apical callosity, forming a tube which is split along its inner surface. This tube is adherent to the transverse plate as far as the latter extends, and is frequently produced beyond its termination.

Muscular scars as in *SPIRIFER*, their anterior portion being divided by a short median septum which is an extension from the apical calcareous deposit.

The brachial valve is spiriferoid in all internal details. The cardinal process is broad, multistriate and supported by a short median thickening. The spirals are large, the primary lamellæ bearing a pair of short, discrete spinous processes which represent the jugum. The shell structure is more or less distinctly and abundantly punctate. It is probable that these punctæ perforate the epidermal layer and extend to the inner lamellæ of the shell. The exterior is usually covered with a finely textile ornament which has been compared, in appearance, to "twilled cloth."



FIG. 287. The primary lamellæ of *Syringothyris typæ*.

Type, *Syringothyris typæ*, Winchell. Burlington limestone.

Distribution. Carboniferous.

Ambocœlia, Hall. 1860.

(Plate 31, figs. 8-17)

Shells small, concavo-, or plano-convex. Marginal outline nearly semi-circular. Hinge-line long and straight, its length nearly or quite equaling the greatest transverse diameter of the shell.

Pedicle-valve greatly elevated; umbo arched and incurved; with a narrow median groove which becomes fainter or disappears toward the anterior margin. Cardinal area well defined and arched; divided medially by an open delthyrium whose lateral margins bear incomplete deltidial plates. Teeth prominent, erect, strongly recurved at the tips; not supported by dental plates. Muscular area quite restricted, consisting of narrow, elongate diductors, inclosing an almost linear adductor. The entire area is sometimes divided by a faint median ridge. The interior surface about the muscular area is strongly pitted.

Brachial valve convex at the beak, becoming depressed over the pallial region and reflexed near the margin. Cardinal area comparatively broad and standing at nearly right angles to the area of the opposite valve. Delthyrium open, the deltidial covering attaining the same degree of development as in the pedicle-valve. Cardinal process narrow and much elongated, resting on the bottom of the valve except at its posterior extremity, which is simply bifurcated. Crural plates erect, parallel; taking their origin in the deltidial plates and extending about one-fourth the distance across the valve. The spirals are attached by long crura, the ribbon making a few volutions only, thus forming loose coils, directed laterally. The jugum has apparently the same incipient condition of development as in *SPIRIFER*. According to EHLERT, the spiral ribbon bears spinules on its outer margins. Muscular impressions anterior and composed of four well-defined adductor scars.

Surface smooth or with fine concentric striæ crossed by indistinct radiating lines; rarely spinous. Shell substance fibrous, impunctate.

Type, *Ambocœlia umbonata*, Conrad (sp.), Hamilton group.

Distribution. Devonian—Carboniferous.

Metaplasia, Hall. 1893.

(Plate 31, figs. 21-24.)

Shells spiriferoid in exterior, with the relative convexity of the valves reversed, the pedicle-valve bearing a median fold and the brachial valve a broad median sinus.

The teeth are stout and unsupported by lamellæ; the posterior extremities of the diductor impressions in the pedicle-valve are deeply impressed and separated by a short, thick septum. Anteriorly the muscular area is less clearly defined; from its distal margin diverge two ridges which were probably of vascular origin, and a few radiating furrows of similar character are seen on the lateral portions of the valve.

In the brachial valve the cardinal process is quite prominently developed and is distinctly bilobed. The socket walls are elevated and recurved; anteriorly they are produced into short crural bases which are not free, but rest upon the bottom of the valve. The muscular area is narrow and elongate and consists of a pair of central adductor scars embraced posteriorly by a broader pair. From the anterior margin of this area arise two vascular trunks which diverge outwardly and recurve, following the margins of the valve. These give off a series of branches externally and probably a shorter series toward the center of the valve. The ovarian markings are very distinct about the bases of the dental sockets. Brachial supports unknown.

The external surface of the shell is smooth or covered with very fine concentric lines. The shell substance is fibrous and apparently impunctate.

Type, *Metaplasia pyxidata*, Hall (sp.). Oriskany sandstone.

But a single species is known.

Verneuilia, Hall. 1893.

(Plate 31, figs. 18-20.)

Shells spiriferoid with a deep median sinus on each valve. The exterior of the valves is divided by two strong divergent ridges into three depressed areas.

Type, *Verneuilia chiroptyx*, d'Archiac and de Verneuil (sp.) Middle Devonian.

Distribution. Devonian — Carboniferous.

Cyrtina, Davidson. 1858.

(Plate 29, figs. 12-26.)

Shells usually of small size and semi-pyramidal contour. Pedicle-valve with a high, vertical or arched cardinal area, which may be unsymmetrical from distortion or unequal lateral growth; this area is divided medially by an elongate-convex deltidium, which may be perforated at any point below the apex, by a circular, direct or oblique foramen, or be without any evidence of such foramen. When present the foramen is accompanied by a sinus on the deltidium, extending from it to the apex of the valve; even when this foramen has been closed from senile deposition of testaceous matter this foraminal groove may remain.

The exterior surface bears a median sinus and more or less distinct lateral plications. On the interior the dental lamellæ are strongly developed and converge rapidly, meeting a median septum from the bottom of the valve. The union consists of a lateral junction of the dental lamellæ with the septum, the latter continuing for a short distance beyond the point of confluence as a vertical ridge, always apparent in the bottom of the spondylium thus formed. At the point of union these three plates constitute a tubular chamber which has no external opening in older shells, and may be filled by organic deposit. The dental plates are shorter than the septum, the latter, at its base, extending beyond the center of the valve, its anterior margin being concave and its inner extremity acute and produced.

Brachial valve very shallow, with narrow, inconspicuous cardinal area. Surface plicated as in the opposite valve. Cardinal process consisting of a double apophysis on the sides of which are strong, divergent crural plates. The spiral cones are elongate-fusiform, each coil attaining its greatest diameter just below the center. They are directed obliquely upward and backward toward the middle of each lateral slope of the pedicle-valve. The jugum is continuous, its branches being directed upward and forward, uniting at their extremities. The muscular impressions comprise two oval anterior, and fainter posterior scars. The surface ornamentation consists of radial plications which may cover both fold and sinus; in rare instances the lateral plications are absent. The concentric growth-lines are sometimes fine and

crowded, at others distant and lamellose; occasionally the surface is coarsely papillose. Shell substance strongly punctate.

Type, *Cyrtina heteroclita*, DeFrance. Middle Devonian.

Distribution. Silurian — Lower Carboniferous.

Bittnerula, gen. nov.

Shells small, cyrtiniform; exterior smooth, substance highly punctate. Umbo of the pedicle-valve deformed or cicatrized, evincing attachment in early growth stages. Interior of the pedicle-valve with a short median septum, attached to the valve for one-fourth the length of the latter, becoming free and



FIGS. 288-292. *Bittnerula Zitteli*, Bittner (sp.). (BITTNER.)

elevated toward its anterior extremity. This septum rises almost to the delthyrium where it joins two greatly abbreviated dental plates which thus form a transverse platform beneath the deltarium.

Type, *Bittnerula Zitteli*, Bittner (sp.)

Distribution. Trias.

Spiriferina, D'Orbigny. 1847.

(Plate 31, figs. 1-7.)

Shells resembling *SPIRIFER* in external aspect; interiorly the pedicle-valve bears a median septum resting upon the bottom of



FIG. 293. The jugum of *Spiriferina Kentuckiensis*, Shumard.

the valve, its posterior portion lying between, but not united with the strong dental lamellæ. The process on the primary

lamellæ are continuous, forming a simple transverse or subacute jugum.

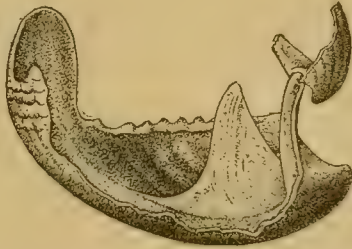


FIG. 294. *Spiriferina Walcottii*, Sowerby; showing muscular scars on walls of median septum of pedicle-valve.

Shell substance strongly punctate throughout.

Type, *Spiriferina rostrata*, Schlotheim (sp.). Lias.

Distribution. Devonian (?) — Jurassic.

Thecocyrtella, Bittner. 1862.

Synonym; *Cyrtotheca*, Bittner, 1890.

Minute shells similar to *CYRTINA* in exterior and interior, but attached by the apex of the pedicle-valve. Surface smooth.



FIGS. 295-298.—Internal casts of *Thecocyrtella ampezzana*, Bittner, sp. (BITTNER.)

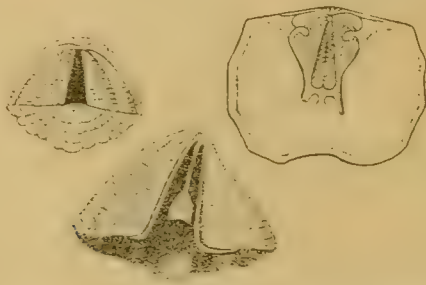
Type, *Thecocyrtella ampezzana*, Bittner.

Distribution. Triassic.

Suessia, Deslongchamps. 1854.

Shells, cyrtiniform, with high, often arched cardinal area; deltidial covering absent or lost. Surface plicate, with median fold and sinus on brachial and pedicle-valves respectively. On the interior of the pedicle-valve are two small dental plates which do

not extend to the bottom of the valve. Between these arises a large median septum which is horizontally expanded at its summit and toward its interior margin. In the brachial valve the dental sockets are deep, the hinge-plate very large, formed by the horizontal expansion and union of the crural plates and producing a plat



FIGS. 299-301. — *Suessia costata*, Deslongchamps; showing the structure of the pedicle and brachial-valves. (Suess.)

form which extends to the middle of the valve. This plate bears the impressiom of the adductor muscles. The primary lamellæ of the spiral coils are united by a jugum bearing a median process directed anteriorly.

Type, *Suessia costata*, E. Deslongchamps.

Distribution. Jurassic.

Whitfieldella, Hall. 1893.

(Plate 32, figs. 1-9.)

Shells usually of small size; valves subequally convex, ovate or elongate in outline. Umbo of the pedicle-valve not high or greatly incurved, usually exposing the circular apical foramen, beneath which the deltidial plates are frequently retained. Cardinal slopes of both valves broad and not distinctly defined; anterior margin subtruncate and gently sinuate. In the typical forms there is a faint sinus on both valves near the anterior margin, otherwise the surface is smooth. On the interior the muscular impressions of the pedicle-valve are similar to those of *MERISTELLA*. In the brachial valve the hinge-plate is concave, divided by a deep central concavity which is supported by a median septum. On either side are lobes bearing the bases of the crura. The brachidium consists of two spiral cones arranged

as in *MERISTA*, but as a rule the ribbon makes fewer (from six to twelve) volutions at maturity. The jugum is simple, the branches being more nearly erect than in *MERISTA*, *MERISTELLA*, etc., and



FIGS. 302, 303.—The jugum of *Whitfieldella nitida*, Hall.

beyond their junction continued into a short, acute, generally slightly curved process, which makes a large angle with the direction of the lateral branches. The muscular impressions, which are very faint, are divided, longitudinally, by the median septum, and transversely, into anterior and posterior scars. From the ante-lateral margins of the muscular area in both valves radiates a series of vascular sinuses, the principal trunks of which are very conspicuous; this feature, however, is rarely retained. External surface of the valves smooth or concentrically striate. Shell-substance fibrous, impunctate.

Type, *Whitfieldella nitida*, Hall, (sp.). Niagara group.

Distribution. Upper Silurian — Lower Devonian.

Hyattella, Hall. 1893.

(Plate 32, figs. 10–17.)

Shell compactly subpentahedral; the umbo of the pedicle-valve acute, concealing most of the deltidial covering. The pedicle-valve bears a strong median sinus and two faint lateral sinuses, the opposite valve having corresponding folds. The surface of the shell and the ante-lateral margins are deeply sinuate. Fine, sharp, closely crowded concentric striae cover the exterior.



FIG. 304.—The loop of *Hyattella congesta*, Conrad.

The interior of the pedicle-valve has a deep and strongly striate pedicle-cavity, bounded by strong dental lamellæ; the diductor scars are distinctly defined, inclosing a linear adductor. In the brachial-valve the hinge-plate is triangular and divided medially by a deep cleft. The lateral portions are broad and elevated,

supporting short, straight crura. The spiral ribbon makes not more than six volutions, forming very loose coils. There is no median septum.

Type, *Hyattella congesta*, Conrad (sp.).

Distribution. Middle Silurian.

Dayia, Davidson. 1881.

(Plate 32, figs. 21-25.)

Shells small, subtriangular in contour, with a very convex pedicle-valve which may be obscurely keeled along the middle and depressed laterally. Brachial valve convex posteriorly, but becoming concave over the anterior region, and bearing a well-developed median sinus. The hinge-line is short; the cardinal area absent. The umbo of the pedicle-valve is gibbous and its apex closely incurved, concealing the foramen. Deltidial plates were probably developed, but they appear to be invariably lost in separated valves. The delthyrium is wide, the teeth divergent, moderately conspicuous and unsupported by lamellæ. In the bottom of the valve are two narrow, divergent muscular grooves, bordered on their anterior edges by thickened ridges, both having the shape of a broad inverted V.

In the brachial valve the character of the hinge-plate was probably simple, and supported by a median septum traversing about one-half the length of the valve; on either side of this septum are the lateral members of the adductor impression. The crura are short and straight; the primary lamellæ are attached to them by a subrectangular curve and pass outward just within the margin of the valve. The spirals are but slightly elevated and have their apices directed outward toward the lateral slopes of the opposite valve. The ribbon makes but three or four turns, and its outer anterior edges are quite coarsely fimbriated. The jugum is situated anteriorly, taking its origin near the upward turn of the primary lamellæ; it is directed upward and backward, the lateral processes meeting at or just behind the center of the interior cavity. From the point of union proceeds a short, simple process, which does not make an angle with the rest of the jugum.

Type, *Dayia navicula*, Sowerby (sp.). Wenlock limestone.

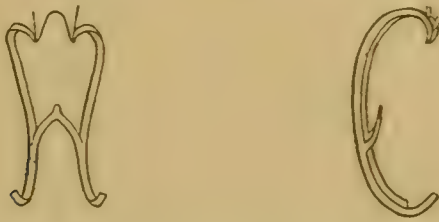
But one species has been recognized.

Hindella, Davidson. 1882.

(Plate 32, figs. 18-20.)

Shells subcircular or elongate-ovate in outline; valves convex, the pedicle-valve being gibbous in the umbonal region. The hinge-line is very short but the cardinal slopes are frequently long and transverse, which, with the fulness of the beaks of both valves, produce a "shouldered" appearance. There is a low sinus on the pedicle-valve which is apparent only over the pallial region; this is accompanied by a slight fold on the opposite valve.

The apex of the pedicle-valve is closely incurved, concealing both deltidial plates and foramen. On the interior the teeth are moderately prominent and are supported by strong dental plates,



FIGS. 305, 306. The primary lamellæ and jugum of *Hindella umbonata*, Billings (sp.).

which not only extend to the bottom of the valve, but are continued forward for about one-third the length of the shell, and inclose a narrow, elongate muscular area. In the brachial valve the hinge-plate appears to be short and constructed on the same plan as that of *MERISTINA* and *WHITFIELDELLA*, with two diverging crural bases divided by a median groove, or a subtriangular pit, and is supported by a median septum extending for about one-half the length of the valve. Spirals everted; jugum situated anteriorly, very depressed, the lateral processes being directed backward in a low upward curve, uniting to form a short, straight undivided stem. External surface smooth. Shell-structure fibrous, impunctate.

Type, *Hindella umbonata*, Billings (sp.).

Two species are known, both from the Middle Silurian.

Meristina, Hall. 1867.

(Plate 33, figs. 1-7.)

Synonym; *Whitfieldia*, Davidson, 1882.

Shells biconvex, the greatest depths of the valves being subequal. General expression meristoid. The beak of the pedicle-valve is erect in youth, but so greatly incurved at maturity as to totally conceal the foramen and deltidium. Cardinal slopes narrow but distinct, forming prominent shoulders which may be traced nearly to the middle of the lateral margins. A low, often indistinct median ridge extends from the apex forward; at about the middle of the shell it is divided by a faint groove, becoming broader toward the margin and continued into a subnasute extension. Lateral slopes scarcely depressed.

The brachial valve also bears a low median ridge, which manifests itself most conspicuously over the anterior portion of the shell.

On the interior of the pedicle-valve the teeth are conspicuous and are supported by thin plates, which extend to the bottom of the valve and are produced forward to form the lateral boundaries of the muscular area. Between the posterior portion of these plates lies the deep scar of the pedicle-muscle, which is separated from the elongate and radially striate diductor impression by a prominent callosity.

In the brachial valve the hinge-plate is deeply divided in the middle by a narrow sulcus, the two lateral lobes being elevated, and supporting the crural bases. The plate is thickened on the under side and supported by a median septum, which extends for one-half the length of the valve. The crura are short and straight, and the primary lamellæ of the spiral ribbon originate from them at a sharp angle, diverge laterally as they turn downward, passing over a portion of the secondary volutions, approach each other toward the middle of their length, nearly meeting at the anterior edge of the median septum, thence again diverging to their anterior recurvature. The secondary volutions do not follow precisely the curvature of the primary lamellæ and the resultant cones at maturity have a gracefully undulated surface. The jugum consists of two lateral branches, broad at their origin,

inclined backward, and uniting to form a stem which bears a short bifurcation at its extremity.

The muscular area is elongate-ovate and more or less distinctly separated into anterior and posterior scars. Surface of the valves smooth or with fine concentric growth striæ. Shell-substance fibrous, impunctate.

Type, *Meristina Maria*, Hall. Niagara group.

Distribution. Silurian.

Glassina, Hall. 1893.

Shells small, biconvex, smooth. Spirals everted; jugum forming neither athyroid saddle nor upright stem, but giving off at the junction of the lateral branches two linear processes; the whole apparatus having thus the form of an inclined X, with its upper tips curved outward.

Type, *Glassina leviuscula*, Sowerby (sp.). Wenlock limestone. But one species has been recognized.

Merista, Suess. 1851.

(Plate 33, figs. 8-15.)

Synonym; *Camarium*, Hall, 1859.

Shells transverse or elongate, both valves generally inflated; anterior margin sinuate, producing a fold and sinus on the marginal portion of the brachial and pedicle-valves respectively.

In the pedicle-valve the apex is perforated by a circular foramen, which, however, is usually concealed at maturity, by the incurvature of the beak; deltidial plates rarely retained. On the interior the teeth are prominent and are supported by dental plates which extend either for a short distance into the interior cavity or are considerably produced at their bases as thickened ridges. Between the dental plates is an arched free plate (the "shoe-lifter" process) attached by its posterior and lateral margins, but at its anterior margin extending beyond the dental lamellæ and rising in a low, broad curve. In rare instances this process, from its origin, bears a sharp median carina which makes the anterior margin highly angulate. The muscular area appears to be limited to the space between the dental lamellæ and to the surface of the "shoe-lifter."

In the brachial valve a median septum is more or less strongly developed and divides a simple ovate adductor impression. The hinge-plate is short and deeply divided by a median groove. The brachial supports consist of spiral cones with their bases in apposition and parallel to the axial plane of the shell, and their apices directed toward the lateral margins. The jugum has been shown by GLASS to have the following structure: The lateral branches approach and unite near the middle of the interior cavity, forming a very short stem, from the posterior extremity of which is given off a pair of arms. These curve



FIG. 307.—The spirals and jugum of *Merista herculea*, Barrande. (DAVIDSON, from a preparation by GLASS.)

downward to the primary lamellæ of the coil and returning meet the lateral branches below their point of union, the whole forming a scissors-shaped arrangement essentially like that of *MERISTELLA*, differing only in minor respects indicated under the discussion of that genus.

External surface of the valves smooth or with concentric growth-lines. Shell-substance fibrous.

Type, *Merista herculea*, Barrande. Etage E.

Distribution. Upper Silurian.—Devonian.

Dicamara, Hall. 1893.

(Plate 33, figs. 16-19.)

Meristoid shells with a "shoe-lifter" in each valve; that of the brachial valve being divided by a vertical median septum.

Type, *Dicamara plebeia*, Sowerby (sp.).

Distribution. Devonian.

Meristella, Hall. 1859.

(Plate 34, figs. 1-11.)

Shells having the same general external characters as *MERISTA*. Valves convex, often inflated, cardinal areas obscure. The umbo of the pedicle-valve is incurved at maturity, concealing most, if not all, of the foramen; in early stages of growth, however, the beak is more erect and exposes the deltidial plates in an elementary condition of development. The anterior margin of the shell is sinuate, and usually there is a sinus on the pedicle-valve, with a less conspicuous fold on the brachial valve; sometimes both valves bear a low sinus, or the sinus on the pedicle-valve may be absent, while the fold on the brachial valve is present, thus giving the shell a nasute anterior extension; again, fold and sinus may be absent on both valves.

In the interior of the pedicle-valve the delthyrium is wide, its margins being thickened into dental ridges. The teeth are conspicuous, often much thickened and curved backward at their tips, interlocking with the opposite valve in such a manner as to make a very firm articulation. The teeth are supported by lamellæ which rest upon the bottom of the valve and are continued for a short distance about the posterior margin of the muscular impression. In old shells this portion of the valve becomes greatly thickened, the muscular impression correspondingly deepened and the identity of the dental lamellæ is obscured by their becoming merged with the substance of the valve. The pedicle-cavity is deep and frequently shows a strong muscular scar. The impression of the diductor muscles is subquadrate-ovate or subtriangular in outline, very strongly impressed and usually clearly divisible into its two lateral components. The central adductor scar is faint, but linear when retained. The lateral scars are deeply striated longitudinally. The anterior margin of the muscular area is frequently obscure but is not infrequently a ridge from which radiate fine, anastomosing pallial sinuses. In the post-lateral regions the ovarian sinuses are sometimes retained.

In the brachial valve the beak is depressed and sometimes obscured by the incurvature of the umbo of the opposite valve. The dental sockets are narrow and divergent. The hinge-plate is subject to some unessential variation in form. Usually it is

triangular, concave on the upper surface and divided into two lobes by a median groove. The crura take their origin from just within the anterior margins of the lobes thus formed. In some species the hinge-plate is more subquadrate in outline, the variation being produced by the development of post-lateral expansions. This plate is supported by a median septum, which extends for somewhat more than one-third the length of the valve. The crura are short and straight, and the primary lamellæ of the brachidium originate from them at an acute angle, and come into closest apposition at the anterior extremity of the median septum. In the mature individual, the spiral ribbon makes about fifteen volutions, the bases of the cones being subparallel to the longitudinal axis of the shell and their apices directed toward its lateral margins. In their general shape the



FIGS. 308, 309.—The jugum of *Meristella Walcottii*.

cones conform to the character of the interior cavity, and in the less convex species (*M. Walcottii*, *M. lenta*), they are appressed on the side of the flatter or brachial valve. The structure of the jugum is the same as described for the genus *MERISTA*, with this difference, however: the circular arms of the jugum curve first outward in the horizontal plane, then backward and abruptly downward to the inner edges of the primary lamellæ; in their return the same curvature is reversed and they, therefore, meet the stem of the jugum in the horizontal plane, their point of union being invariably above the point of coalescence of the lateral branches of the jugum.

The muscular area is elongate-ovate, and extends for the entire length of the median septum; the four adductor scars are sometimes distinctly seen, the posterior pair being broader and embracing the posterior extremities of the anterior scars.

External surface of the valves smooth or with concentric striæ.
Shell-structure fibrous, impunctate.

Type, *Merista lævis*, Hall. Lower Helderberg group.

Distribution. Devonian.

Dioristella, Bittner. 1890.

Smooth shells having a jugum whose lateral branches return upon themselves, somewhat as in *MERISTELLA*.



FIG. 810.—Jugum of *Dioristella indistincta*, Beyrich (sp.). (BITTNER.)

Type, *Dioristella indistincta*, Beyrich (sp.).

Distribution. Triassic.

Charionella, Billings. 1861.

(Plate 34, figs. 12–14.)

Shells meristoid in exterior and probably in the structure of the brachidium and jugum. Hinge-plate greatly modified, its appearance being that of two ridges, strongly recurved at their edges, passing along the margins of the delthyrium and inclosing the dental sockets; these are supported by thin lamellæ which converge toward the bottom of the valve; the crura arising from the extremities of the lateral ridges are short and curved outward; the central portion of the plate must be considered as absent, or as very concave and merged in the substance of the valve.

Type, *Charionella scitula*, Hall (sp.) Corniferous limestone.

Pentagonia, Cozzens. 1846.

(Plate 34, figs. 15–20.)

Synonym; *Goniocœlia*, Hall, 1861.

Shells with a very broad sinus on the pedicle-valve, which is limited by divergent carinæ, outside of which the cardinal or lateral slopes are very abrupt. On the brachial valve is a rounded median fold, which may be divided on its summit by a narrow sinus, and in the umbo-lateral region are two short folds

or flanges, beginning at the hinge-line, having a slightly sinuous curve and terminating before traversing much more than one-third the length of the valve; occasionally there is a second of these ridges on each side.

The muscular impressions of the valves are essentially as in *MERISTELLA*. The hinge-plate has a peculiar structure; it arises vertically from the bottom of the valve, presenting an erect, concave anterior face, which is traversed by a faint median ridge continuous with the septum of the valve. The posterior portion of the upper surface of this plate bears a deep circular or crescentic concavity, most sharply defined on its anterior edge where it is bounded by the somewhat recurved vertical wall. On the lateral portions of the upper face of the anterior wall lie the elongate crural bases which are continued into short, straight crura, standing at an angle of about forty five degrees to the plane of the horizontal face of the plate. The spiral cones are as in *MERISTELLA*, their curvature conforming to the peculiarly contracted interior cavity of the shell. Precise nature of the jugum not known.

Type, *Pentagonia unisulcata*, Conrad (sp.).

Distribution. Devonian (Upper Helderberg and Hamilton groups).

Camarospira, Hall. 1893.

(Plate 33, figs. 20-23.)

Shells essentially meristelloid in external and internal characters. The important difference from allied genera lies in the fact that the dental plates of the pedicle-valve, instead of resting upon the bottom of the valve, are more strongly convergent than in *MERISTA*, *MERISTELLA*, etc., uniting before they reach the internal surface of the valve, thus restricting the impression of the pedicle-muscle to a distinct chamber or spondylium, which is supported by a low median septum. In the typical species this chamber has the same extent as the deep pedicle-cavity in *MERISTELLA*, that is, about one-fourth the length of the valve, while the septum extends for a short distance beyond its anterior margin, dividing the scars of the adductor and diductor impressions. In this respect the internal structure of this valve is similar to that of the corresponding valve of *PENTAMERUS*.

In the brachial valve the hinge-plate is supported by a median septum slightly longer than that of the opposite valve, and the narrow, cordate muscular impression, which it divides medially, is considerably thickened. The valve bears everted spirals similar to those of other members of this group, but the specimens studied were not in a condition of preservation adapted to the determination of the structure of the jugum.

Type, *Camarospira Eucharis*, Hall. Corniferous limestone.

Athyris, McCoy. 1844.

(Plate 35, figs. 1-8.)

Synonyms; *Spirigera*, D'Orbigny, 1847; *Euthyris*, Quenstedt, 1871.

Shells subequally biconvex; outline transversely elliptical, subcircular or elongate-subovate; surface medially sinuate.

In the pedicle-valve the umbo is inconspicuous and incurved, usually concealing the foramen and deltidial plates; frequently, the former is exposed. Cardinal slopes not well defined in the typical group. The convexity of the valve is greatest in the umbonal region, the surface sloping evenly to the sides, and becoming depressed on the median line into a sinus, which is most prominent on the anterior margin. Beak of the brachial valve not prominent; a median fold corresponds in strength to the sinus of the opposite valve.

In the interior of the pedicle valve the deltidial plates are usually absent; the teeth are prominent, recurved at the tips, and supported by stout dental lamellæ, which are not produced anteriorly about the muscular area. Between them lies a deep, transversely striated pedicle-cavity, and in front of this an ovate muscular scar extending about one-half the length of the valve and divided into flabellate diductors (which are frequently very indistinct) and narrow, cordate adductors. The pallial region is covered with ovarian pittings and branching sinuses.

In the brachial valve the dental sockets are broad and deep. The hinge-plate varies considerably in form; in the typical division of the genus it is subtriangular in outline, and supported by stout crural plates. The median portion is flat or concave, the lateral margins thickened and elevated. At the apex of the plate

and just within the beak of the valve is a circular perforation (visceral foramen), which is continued beneath the plate into the cavity of the valve. The anterior margin of the plate is straight or slightly concave, occasionally trilobate, and the crura are attached at the extremities of the lateral ridges. Sometimes the outline of the hinge-plate is rendered subquadrate by the development of two post-lateral expansions.

The brachidium consists of spiral cones lying base to base, with their apices directed laterally. The form of these cones varies with that of the internal cavity, but as a rule they are much compressed vertically, the posterior curvature being short and convex,

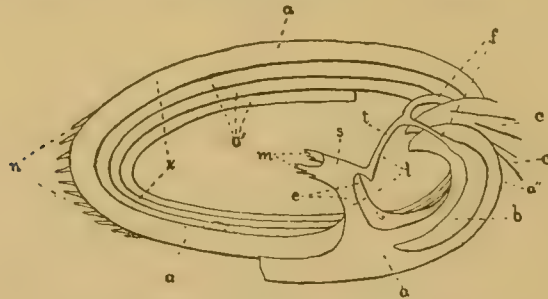


FIG. 311.

Diagram of the structure of the brachidium in *ATRYPA*.

- | | |
|---|--|
| <i>x.</i> Spiral coll. | <i>s.</i> Saddle. |
| <i>a.</i> Primary lamellæ of spiral coll. | <i>m.</i> Fimbriated extensions of saddle. |
| <i>a'.</i> Secondary lamellæ. | <i>t.</i> Stem of jugum. |
| <i>a''.</i> Umbonal blades. | <i>f.</i> Arms of jugum. |
| <i>c.</i> Crura. | <i>b.</i> Accessory lamellæ. |
| <i>l.</i> Jugum. | <i>n.</i> Fimbriæ on outer margins of lamellæ. |
| <i>e.</i> Lateral branches of jugum. | |

while the anterior curve is long and sometimes depressed. The crura originate from the hinge-plate at a large angle, are long and convergent, the primary lamellæ beginning at their extremities, making an angular curve at their origin, thence, in the typical species, curving deeply upward and backward, to form the first volution. The spirals are connected by a jugum, which takes its origin on the first half of the primary lamellæ, the two lateral lamellæ converging, and uniting at about half the distance across the base of the cones, to form a broad saddle with a convex upper surface; the anterior extremity of this saddle may be simple or divided; its posterior portion is narrowed,

inclined downward or toward the beak of the brachial valve for a short distance, thence it rises abruptly toward the umbo of the pedicle-valve, and bifurcates near the extremities of the crura, each branch following the curvature of the primary lamellæ and continuing for only a part of the distance between the ends of the crura and the origin of the jugum. These accessory lamellæ vary somewhat in form, are narrower than the ribbon of the coil, and lie between the primary, and the first band of the secondary lamellæ.

The muscular area consists of a long, ovate scar, which is divided into a subquadrate posterior pair, and a subcordate anterior pair of adductor impressions. These are separated longitudinally by a very faint median ridge. On casts of the interior the filling of the visceral foramen in the hinge-plate frequently shows a cross-striation like that of the pedicle-cavity of the opposite valve, and also indicates that the median ridge is continued throughout the extent of this passage.

The surface of the valves is variously ornamented; in the typical group, at each concentric growth-line, there is a broad lamellar expansion; in some cases this expansion is striated longitudinally, or it may be divided into flat spines, which merge into the lamella at their bases; again the spines may be long and tubular, but connected by the laminar expansions. The surface frequently appears to be smooth or covered only with concentric striæ, and in one of the largest subdivisions of the genus (*SEMINULA*) it is a normal condition, while in other divisions it is often wholly casual.

Shell-substance fibrous, impunctate.

Type, *Athyris concentrica*, von Buch (sp.). Middle Devonian.

Distribution. Upper Silurian (?) — Carboniferous.

Subgenus **Cliothyris**, King. 1850.

(Plate 35, figs. 9, 10.)

Shells with surface ornamentation consisting of broad, thin, lamellar expansions, which are divided almost, sometimes quite to their bases into long, flat spinules; the hinge-plate is narrow and rather acutely triangular; the primary lamellæ are attached to the crura not only at their apices but for a short distance along

their inner faces, not making the nooses peculiar to *ATHYRIS* proper; they are broad and blade-like, narrowing beyond the insertion of the jugum; the jugum is situated posteriorly; the accessory lamellæ are narrow near their origin, broaden and then taper again, having the shape of a sickle. The spiral ribbon

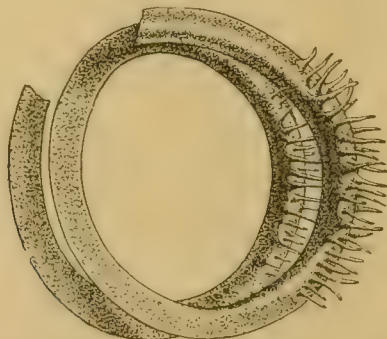


FIG. 312.—The fimbriated spirals of *Cliothyris pectinifera*, Sowerby (sp.). (DAVIDSON.)

appears, from the figures given by DAVIDSON and KING, to be pectinated on all its outer edges, but it has not been shown that the anterior extremity of the jugum is similarly ornamented

(Type, *Cliothyris pectinifera*, Sowerby (sp.). Lower Carboniferous — Permian.)

Subgenus *Actinoconchus*, McCoy. 1844.

Shells characterized by the extravagant development of the concentric lamellar expansion, which are striated radially by distant sulci. These expansions appear to be actually fine, tubular spines connected by, or imbedded in a tenuous calcareous plate. The interior of the pedicle-valve bears a median septum which traverses the pedicle-cavity and half the length of the shell; also two strong dental plates which are continued forward, slightly diverging, for more than one half the length of the septum. Mr. DAVIDSON has given elaborate illustrations of the spirals and loop of this species, from preparations by the Rev. NORMAN GLASS, and from them it appears that the latter organ, the jugum, has essentially the same conformation as in *Cliothyris pectinifera*, though placed further forward. The saddle of the

jugum is neither divided nor pectinated, while the spiral ribbon bears short spinules on the edge and face of the lamellæ fronting the sides of the shell.

(Type, *Actinoconchus planosulcatus*, Phillips (sp.). Carboniferous.)

Subgenus **Seminula**, McCoy. 1844.

(Plate 35, figs. 11-19.)

Shells transverse, often elongate or ficiform; valves biconvex, the pedicle-valve with a median sinus over the pallial region, and the brachial valve with a corresponding ridge; both sinus and fold may be divided by a sharp median sulcus extending from the umbones to the margins. There is frequently evidence of a single obscure lateral fold on each side of both valves. The umbo of the pedicle-valve is incurved and the deltidial area is usually concealed; the foramen, however, is exposed



FIGS. 313, 314.—The jugum of *Seminula subtilita*, Hall.

as a circular or ovate aperture which encroaches on the substance of the valve. In the pedicle-valve the diductor muscular impressions are very faintly defined; the adductor and pedicle impressions are as in the typical forms of *ATHEYSIS*. In the brachial valve the hinge-plate is highly developed, its upper face being subquadrate in outline, concave on the surface, the concavity deepening toward the visceral foramen which lies just beneath the beak; not infrequently the foramen is closed by secretions of testaceous matter. The posterior flanges of the plate pass beyond the hinge-line and into the umbonal cavity of the opposite valve. The anterior face of the plate is erect and the anterior edge somewhat

trilobed, the lateral lobes bearing the crural bases. The crura are straight and their attachment to the primary lamellæ is of the same character as in *CLIOTHYRIS*, etc. The primary lamellæ, on the umbonal curve, are broad, the jugum usually situated posteriorly. The saddle of the jugum is often bilobed on its anterior margin, and frequently both it and the outer margins of the ribbon of the secondary volutions are fimbriated.

The muscular impressions of this valve are very narrow, and subdivided into two pairs of elongate scars. The members of the posterior pair are divided by a median septum or ridge, which begins beneath, though it does not support the hinge-plate. Branching vascular sinuses are sometimes retained over the pallial region of both valves.

Surface of the valves smooth, that is, with sharp, concentric striæ which were never produced into lamellæ.

(Type, *Seminula ambigua*, Sowerby (sp.). Carboniferous.)

Subgenus *Spirigerella*, Waagen. 1883.

Shells elongate transverse; contour showing a decided tendency to plano-convexity, the pedicle-valve being depressed by a broad, flat sinus, and the brachial valve considerably elevated;



FIG. 315.—Jugum of *Spirigerella Derbyi*, Waagen. (WAAGEN.)

cardinal slopes more or less pronounced; surface smooth or with sharp, concentric growth-lines, which were not produced into lamellæ or spines. On the interior the hinge-plate is high, the anterior face being erect, the upper face subquadrate in outline and concave, the posterior face extending considerably beyond the hinge; it is perforated by a visceral foramen. The jugum is situated pretty well back and its structure is essentially like that in *Actinoconchus planosulcatus*; in *S. Derbyi*, however, the saddle of the jugum, which is entire on its anterior margin, bears a median septum on its summit, extending from its anterior edge to the bifurcation of the stem; a feature not elsewhere observed among the athyroids, except in *KAYSERIA*.

(Type, *Spirigerella Derbyi*, Waagen. (?) Carboniferous.)

Tetractinella, Bittner. 1890.

Synonym; *Plicigera*, Bittner, 1890.

Shells with four corresponding ribs on each valve; spiral cones directed laterally; jugal branches erect, uniting in an elongate



FIGS. 316-318.—*Tetractinella trigonella*, Schlotheim (sp.) (BITTNER).

narrow and nearly vertical saddle from the posterior extremity of which short intercalary lamellæ are given off.

Type. *Tetractinella trigonella*, Schlotheim (sp.).

Distribution. Triassic.

Subgenus Pentactinella, Bittner. 1890.

FIGS. 319, 320.—*Pentactinella quinquecostata*, Münster (sp.). (BITTNER)

Shells with five corresponding ribs on each valve. Interior as in TETRACTINELLA.

(Type, *Pentactinella quinquecostata*, Münster (sp.). Triassic.)

Subgenus Anomactinella, Bittner. 1890.

FIGS. 321, 322.—*Anomactinella flexuosa*, Münster (sp.). (BITTNER.)

Shells with a number of ribs sharply developed toward the margins. Interior probably as in TETRACTINELLA.

(Type, *Anomactinella flexuosa*, Münster (sp.). Triassic.)

Amphitomella, Bittner. 1890.

Smooth shells with a very strong double cardinal process, and a median septum in each valve extending the entire length of the shell and dividing the cavity into two chambers. Jugum

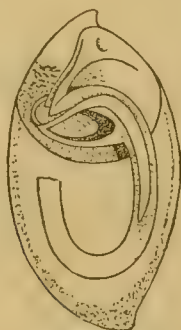


FIG 323.—*Amphitomella hemisphaeroidica*, Klipstein (sp.). (BITTNER.)

situated posteriorly; saddle scarcely developed; intercalary lamellæ extending for nearly the entire length of the primary lamellæ.

Type, *Amphitomella hemisphaeroidica*, Klipstein (sp.).

Distribution. Triassic.

(?) Pomatospirella, Bittner. 1892.

Shells small, unevenly convex, having the contour of *DAYIA* and *CYCLOSPIRA*. Hinge-line straight, cardinal area absent



FIGS. 324-326.—*Pomatospirella thecidium*, Bittner. (BITTNER.)

Shell smooth, fibrous, the fibres converging toward a median line. Interior unknown.

Type, *Pomatospirella thecidium*, Bittner.

Distribution. Triassic.

(This genus is insufficiently characterized. Its known structure does not serve to distinguish it from the other genera mentioned.)

Kayseria, Davidson. 1892.

(Plate 36, figs. 1, 2.)

Shell small, with depressed-convex or lenticular valves, radially plicated exterior and a median, plicated sinus on both valves. On the interior the pedicle-valve bears a low, thickened median ridge, but is otherwise devoid of pronounced peculiarities. In the brachial valve there is a high median septum which arises from beneath the divided hinge-plate and reaches its greatest elevation at a point behind the center of the valve, whence it descends rather abruptly, traversing altogether about two-thirds the length of the valve.

The spiral cones form sharp angles with the crura, and are directed laterally; the jugum is very stout, taking its origin at about one-third the length of the primary ribbon; it is directed somewhat posteriorly, its lateral elements uniting to form a short saddle which rests upon, and is supported by the most elevated part of the median septum. Posteriorly the jugum is continued into an upright simple stem, which is continued completely across the umbonal cavity and comes into contact with the opposite valve, resting upon the median ridge of that valve or with its extremity inserted into a groove upon that ridge. The acces-



FIG. 327.—Approximate determination of the jugum in *Kayseria lens*, Phillips (sp.).

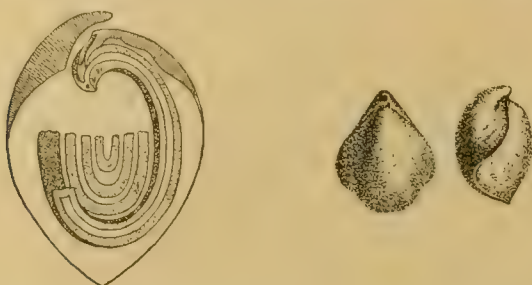
sory lamellæ originate from a posterior elevation or process arising from the saddle of the jugum and are given off at points just in front of the crural angles. The ribbon of the principal spiral cones is comparatively broad, thickened on the inner margins, making six or seven volutions in a full-grown shell. The accessory lamellæ are also produced into spirals which though more delicate are composed of as many volutions as the principal spirals. At their outset the branches of the accessory lamellæ pass between the first and second volutions of the principal ribbon, and the two are intercoiled in this manner for their entire extent.

Type, *Kayseria lens*, Phillips (sp.). Middle Devonian.

But a single species is known.

Pexidella, Bittner. 1890.

Smooth, biconvex shells, with both valves greatly thickened in the umbonal regions. Spiral cones directed laterally; jugum much reduced and situated in the umbonal region; saddle scarcely



FIGS. 328-330. *Pexidella Strohmayeri*, Suess (sp.). (BITTNER.)

developed; intercalary lamellæ narrow and extending for nearly the entire length of the principal coils.

Type, *Pexidella Strohmayeri*, Suess (sp.).

Distribution. Triassic.

Diplospirella, Bittner. 1890.

Smooth, biconvex shells with thickened valves. Jugum well developed, situated posteriorly; saddle narrow, having the form of an oblique stem from the posterior extremity of which are



FIGS. 331-333. *Diplospirella Wissmanni*, Münster (sp.). (BITTNER.)

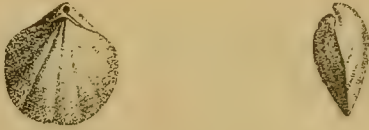
given off the intercalary lamellæ, which are broad, serrate on the outer margin and coextensive with the principal coils.

Type, *Diplospirella Wissmanni*, Münster (sp.).

Distribution. Triassic.

Euractinella, Bittner. 1890.

Shells with short corresponding ribs, obscure cardinal area and double spirals.



FIGS. 334, 335. *Euractinella contraplecta*, Münster (sp.). (BITTNER.)

Type, *Euractinella contraplecta*, Münster (sp.).

Distribution. Triassic.

Anisactinella, Bittner. 1890.

Shells with the ribs on the valves alternating in position; cardinal area, deltarium and cardinal process well developed. Spiral cones duplex, the intercalary cones giving off a process in



FIGS. 336-338. *Anisactinella quadriplecta*, Münster (sp.). (BITTNER.)

umbonal region which returns to join the jugum, as in *MERISTA* and *MERISTELLA*.

Type, *Anisactinella quadriplecta*, Münster (sp.).

Distribution. Triassic.

Retzia, King. 1850.

(Plate 36, figs. 3-7.)

Shell elongate-oval, rather broad over the pallial region. Surface covered with rather coarse, angular, usually simple plications. There is a trace of an indistinct median sinus on the pedicle-valve in which the plications are slightly smaller than those adjoining. The umbo of the pedicle-valve is incurved and its apex truncated by a circular foramen. The deltidial covering is triangular, flat or arched by the incurvature of the beak; the deltidial plates are firmly anchylosed into a single piece and the original line of symphysis is represented by a thickened ridge. The edges of the cardinal area are well defined, but not alate on either valve, the beak and area of the brachial valve being

entirely concealed by incurvature. The cardinal slopes are broad and smooth. On the interior of the pedicle-valve the teeth are rather small and are supported by thin lamellæ which traverse the umbonal cavity and rest on the bottom of the shell.



FIG. 339.

FIG. 340.

FIG. 341.

FIG. 342.

FIG. 343.

FIGS. 339-343 — *Retzia Adrieni*, de Verneuil. Consecutive sections to show internal structure of the umbonal regions.

FIG. 339 — Section across opening of foramen, with umbonal tube open on the back.

FIG. 340 — Section further down, showing attachment of the remnants of the tube to the deltidial plates.

FIG. 341. — Section near the hinge, showing last traces of tube adherent to the thickened deltidial plates.

FIGS. 342, 343. — Sections from another individual, one across the foramen, the other beneath it; showing the continuity of the tube.



FIG. 344.

FIG. 345.

FIG. 346.



FIG. 347.

FIG. 348.

FIGS. 346-358. — *Retzia Adrieni*, de Verneuil.

FIG. 344. — Section just below the foramen; showing the entire umbonal tube.

FIG. 345. — Showing the adherence of the tube to the still divided and discrete deltidial plates.

FIGS. 346, 347. — Sections at the umbo of the brachial valve; showing the internal coalescence of the deltidial plates, and the open tube.

FIG. 348. — Showing the dental lamellæ, and the median septum in the brachial valve.

These lamellæ are produced forward for a short distance, limiting, posteriorly, the muscular area. The apical portion of the umbonal cavity contains a longitudinal tube attached by one side to the inner surface of the deltidial covering. Just within

the outer opening of the foramen this tube appears to have been closed on all sides, but further toward the cardinal margin it becomes split along the back or outer surface, diminishing in size downward and disappearing entirely before the cardinal margin is reached. In sections made across the vertical foramen it is seen that the tube extends within the deltidial covering, and forms a subcircular enfolding of testaceous matter from the margins of the foramen.



FIG. 349.



FIG. 350.



FIG. 351.



FIG. 352.

FIG. 349.—Section just above the apex of the brachial valve; showing the last traces of the deltidial plates, which are here free.

FIG. 350.—Section at the apex of the brachial valve.

FIG. 351.—Section cutting the posterior extension of the median and lateral lobes of the hinge-plate.

FIG. 352.—The same features further down; showing also the appearance of the teeth, and the remnants of the dental lamellæ bordering the muscular area of the pedicle-valve.



FIG. 353.



FIG. 354.



FIG. 355.



FIG. 356.

FIG. 353.—Section through the center of the hinge-plate; showing also the development of the dental sockets.

FIG. 354.—Section showing the ante-median crest of the hinge-plate.

FIG. 355.—The anterior edge of the hinge-plate and its supporting septum.

FIG. 356.—Section in front of the hinge-plate; showing the crura and median septum.

In the brachial valve the hinge-plate is subquadrate on its upper surface, its posterior margin somewhat crescentic, the horns of the crescent extending into the umbonal cavity of the opposite valve; this character, however, is not so highly developed as in *EUMETRIA*. The structure of this plate appears to be essentially similar to that of *HUSTEDIA*; at all events, the tent-shaped crural supports of *EUMETRIA* are absent; there is, however, no trace here of the ligulate, curved process which occurs in

HUSTEDIA, but the median portion of the upper face is convex and the lateral portions deeply grooved and bounded on the outside by the elevated crural bases. The hinge-plate is supported by a strong median septum which extends for nearly two-thirds the length of the valve. It is most highly elevated near the middle of its length where it extends vertically about one-fifth of the distance across the internal cavity; thence it tapers rapidly to its anterior extremity.

The brachidium has been reconstructed from serial transverse sections of the shell in several directions, and the following description may be relied upon as approximately accurate. The umbonal blades of the primary lamellæ are comparatively narrow and considerably incurved at their apices, where attached to the long crura, as in EUMETRIA. The jugum is situated well forward,



FIG. 357.

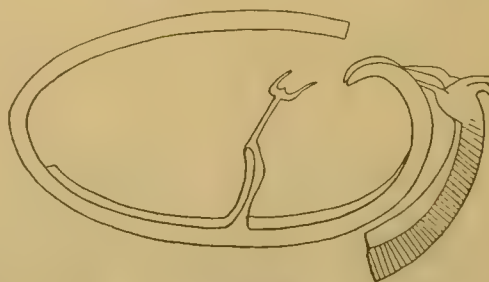


FIG. 358.

The jugum of *Retzia Adrieni*, de Verneuil, as reconstructed from consecutive sections.

just behind the center of the lamellæ; its lateral branches are erect and long; they narrow with a slight twist just above their origin, as in the genera RHYNCHOSPIRA and TREMATOSPIRA, then broaden, curving outward and thence inward to their point of union. The stem is short, making an angle with the lateral branches, and is directed backward. It reaches the level of the crura at a considerable distance in front of them and is there bifurcated, each arm making a slight double or sigmoid curve. These arms are, however, too short to reach the umbonal blades. The stem itself is continued for a short distance above the point of bifurcation. The spiral ribbons make ten or eleven volutions in full-grown individuals. Fimbriæ are absent from both the spirals and jugum.

Type, *Retzia Adrieni*, de Verneuil. Middle Devonian.

But one species is known.

Rhynchospira, Hall. 1859.

(Plate 36, figs. 8-12.)

Shells elongate, retziiform; hinge-line short and curved. Umbo of the pedicle-valve incurved, usually concealing the deltarium; apex truncated by a circular foramen. Cardinal slopes gradual, scarcely excavated, not forming a false area. Deltarium triangular and flat or incurved; its lateral margins are sharply defined, and its surface traversed by a longitudinal median ridge, which is the line of solid coalescence of the constituent plates. The umbonal cavity does not contain the split deltidial tube which is present in the genera *RETZIA*, *HUSTEDIA*, etc. The teeth are small and well defined, and are not supported by dental plates. Muscular impressions very obscure.

In the brachial valve the hinge-plate has the general form of that in *TREMATOSPIRA*, but is much less elevated. Its posterior extension is slight, extending but a short distance beyond the hinge; it consists of two parts, a lower, which is closely appressed against the umbo, and deeply divided by a median cleft; and an upper, which is larger, conspicuously elevated and divided medially only at its margin, though the groove extends forward to the middle of the plate. The anterior portion is deeply concave and produced into two flat lobes which form the crural bases. The entire plate rests on stout supports which diverge at the bottom, leaving a triangular cavity beneath, in which there is a short, sometimes obscure median septum. The spirals make from six to nine volutions, the primary lamellæ being narrow and not greatly incurved. The jugum is situated behind the middle of these lamellæ and is simple in its structure; its lateral branches narrow just above their origin, with a gentle posterior inclination, then broaden and meet at a little more than one-half the distance across the base of the coils, forming a broad, short, roof-shaped process, which is directed posteriorly and terminates in an oblique edge.



FIG. 359.—The jugum of *Rhynchospira formosa*, Hall.

The external surface is radially plicate, the plications being simple. In young shells there is a median sinus on both valves, but as growth advances, that of the brachial valve develops into a low fold. Both fold and sinus bear a number of small, intercalary

plications, much finer than those adjoining on each side. Shell substance rather sparsely punctate.

Type, *Rhynchospira formosa*, Hall. Lower Helderberg group.

Distribution. Devonian—Lower Carboniferous.

Subgenus **Homæospira**, Hall. 1893.

(Plate 36, figs. 13-19.)

Shells similar in exterior to RHYNCHOSPIRA. The hinge-plate has no posterior extension, but its anterior lobes are greatly developed into long, divergent crural bases. They are separated to the apex of the beak and between them lies a small linear cardinal process. There is a stout median septum in the brachial valve whose height is equal to nearly one-half the depth of the valve. The jugum has an acute stem and its lateral branches are of the same width from their origin to the point of union. The deltidial plates frequently remain distinct and uncoalesced at maturity.

(Type, *Homæospira evax*, Hall. Niagara group.)

Ptychospira, Hall. 1893.

(Plate 36, figs. 20-23.)

Shells bearing a few sharply angular radial plications which are greatly elevated at the margins of the shell. The median plication on the brachial valve is usually divided by a fine sulcus, there being a corresponding ridge in the sinus of the opposite valve. The beak of the pedicle-valve is erect, and truncated obliquely by a circular foramen, beneath which lies a flat deltarium, the plates of which are, as in allied genera, more or less completely coalesced. The epidermal layer of the shell is finely pitted, the punctations apparently not continuing into the layers beneath, but producing a superficial ornamentation not unlike that occurring in EICHWALDIA. This ornamented layer extends

even over the surface of the deltidium.

The inner laminæ of the shell are fibrous and more sparsely punctated. There is no deltidial tube in the umbonal cavity of the pedicle-valve. The hinge-

plate appears to be similar to that of RHYNCHOSPIRA, with no prominent

FIG. 360.—The jugum of *Ptychospira ferita*, von Buch (sp.).



posterior extension, but with conspicuous crural bases which are curved upward. The whole process is supported by

a well-defined median septum. The spiral ribbon makes but few (four or five) volutions; the jugum takes its origin behind the middle of the primary lamellæ, its lateral branches being slightly constricted near their bases; it is inclined backward in a broad curve, the union of the lateral branches taking place at a point just within the opposite side of the base of the cones. From this point the stem of the jugum is continued as a simple process, outward between the coils and almost to the inner surface of the pedicle-valve.

Type, *Ptychospira ferita*, von Buch (sp.). Middle Devonian.

Distribution. Devonian — Lower Carboniferous.

Uncites, DeFrance. 1827.

(Plate 36, figs. 24-27.)

Shells usually of large size, elongate-oval or subtriangular in marginal outline; valves convex. The pedicle-valve has a long and acuminate beak which is frequently distorted and always arched or incurved. There is no cardinal area and the hinge-line is greatly curved. There is no foramen in mature individuals though it may be retained in young forms. The deltarium is concave and consists of a single piece, all trace of the original components being lost. The teeth are supported by dental plates and between them lies a broad median ridge which narrows as it approaches the hinge. The brachial valve has a broad, full beak, which is closely incurved and concealed beneath the deltarium of the opposite valve. The cardinal process is large, erect and slightly bilobed on its posterior margin; it rests upon a short plate bearing two ridges which are continued into the bases of the crura. On either side of these ridges and just within the margins of the valve is a strong, oval, concave, pouch-like plate. The crura are very long, passing into the primary lamellæ without interruption. The spirals are relatively small, situated anteriorly, and consist of seven or eight volutions. These are connected by a simple erect jugum, which is situated medially

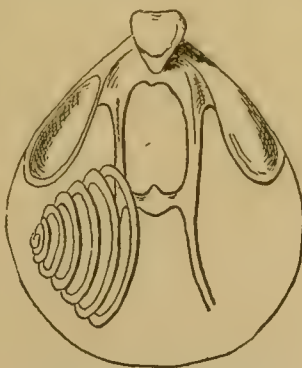


FIG. 361.—Interior of brachial valve of *Uncites gryphus*, Schlotheim; showing cardinal process, marginal pouches, spiral and jugum. (DAVIDSON).

and terminates at the junction of the lateral branches in a short, horizontal process.

External surface of the valves covered with numerous radiating plications; occasionally smooth. Shell-substance fibrous, impunctate.

Type, *Uncites gryphus*, Schlotheim (sp.). Stringocephalus limestone (Middle Devonian).

Uncinella, Waagen. 1883.

(Plate 37, figs. 23-25.)

Shells with a general external resemblance to *RETZIA*. The valves are more or less finely plicated; no sinus or median fold developed; the hinge-line is curved; the beak full and strongly incurved, provided with a distant deltarium; apex truncated by a large oval foramen.

The shell bears spirals of the same general disposition as in *RETZIA* or *UNCITES*, but neither the jugum nor the mode of junction of the primary lamellæ with the crura is known. In the pedicle-valve below the apex of the beak, there is an excavated, small but very distinct deltarium; its composition of two pieces



FIG. 362.

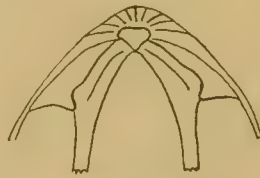


FIG. 363.

Interior cardinal region of pedicle- and brachial valves of *Uncinella indica*, Waagen. (WAAGEN.)

has not, however, been made out. It does not reach to the hinge-line, but is cut out below for the reception of the apex of the small valve. Hinge-teeth long and not supported by dental plates.

In the brachial valve the apex is flattened, and no cardinal process is present. At the apex two sharp ridges take their origin, limiting the dental sockets on the other side. These latter are elongated, deep, triangular. There is no hinge-plate, but the crura take their origin immediately at the apex, sloping strongly toward the middle line, and very nearly reaching the bottom of the valve.

Type, *Uncinella indica*, Waagen.

Distribution. Carboniferous.

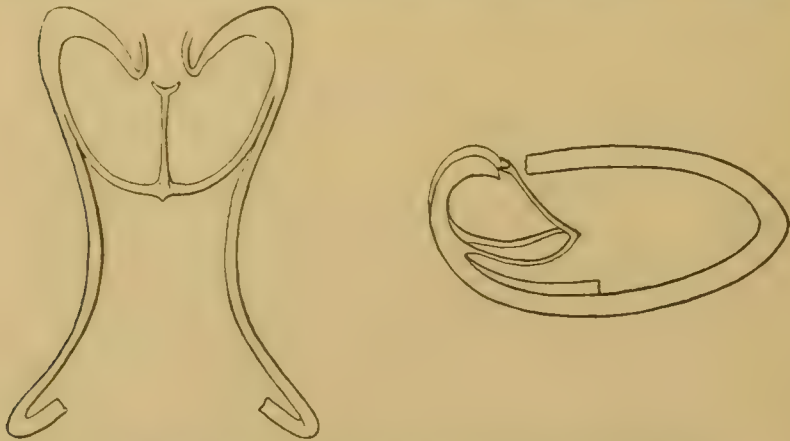
Eumetria, Hall. 1863.

(Plate 37, figs. 1-12.)

Shells elongate-terebratuliform; outline ovate. Valves subequally convex. Hinge-line short; cardinal area of the pedicle-valve somewhat elevated, primarily composed of symmetrical deltidial plates. In the adult condition the line of symphysis between these plates is lost, or represented by a faint line, giving the deltarium the appearance of a single vertical, or slightly incurved plate, sharply defined on its lateral margins. The foramen is apical, its lower side only encroaching on the deltarium. The cardinal extremities are slightly alate, a feature more noticeable on the brachial valve and which gives this valve a somewhat pectenoid appearance. On the interior of the pedicle-valve the teeth are of moderate size, but otherwise the shell is nearly devoid of markings of any kind. There is no apical foraminal tube as in *RETZIA*, no dental lamellæ or muscular ridges, and only in extremely rare instances is there any trace of the muscular impressions.

In the brachial valve the structure of the hinge-plate is very complicated. It may be described as composed of two parts, a posterior and an anterior. The posterior portion is rather broadly crescentic in form, having the curvature of the umbonal margin of the valve; its lateral extensions form the socket-walls, which are moderately broad, deep and well defined. On the central portion of this part of the plate rests a second crescent, having its horns, which make nearly a semi-circle, directed backward and into the umbonal cavity of the opposite valve. At this point the curvature of the plate is such that the base of the crescent lies upon the inner surface of the deltarium of the pedicle-valve, its horns crossing the deltarium, extending for fully half the length of the umbonal cavity, and being elevated, at their tips, above the inner surface of the shell. The posterior part of the hinge-plate is connected with the anterior part only by a narrow, thickened median band, which is constricted transversely at the point of union, the transverse groove being crossed only by a very fine axial ridge. The anterior portion of this plate consists of a long, narrow, triangular, concave or spoon-shaped central process, the edges of which are sharply elevated, and the extremities of these marginal ridges are produced into two

long, slender and nearly vertical crura. The hinge-plate is not connected with the lateral portions of the shell, but is supported by two slightly divergent, upright lamellæ which extend to the bottom of the valve; as the valve in this region is deep, these lamellæ are very conspicuous. The crura widen as they approach the apices of the primary lamellæ, and form their union with these by a short, abrupt lateral curve. The spiral cones are approximate, their apices lateral, the ribbon making eight or nine volutions in the adult individual. The umbonal blades are broad for one-third their length, narrowing abruptly in front of the jugum. The jugum is situated posteriorly, and is constructed as follows: Two slender lateral processes are given off from the primary lamellæ, which are directed forward in low, down-



FIGS. 364, 365. Two views of the jugum of *Eumetria Verneuiliana*, Hall.

ward curves, and near their extremities turn inward and upward, meeting at a point just behind the center of the shell-cavity. From their point of union a single process is extended backward at an abrupt angle and with a very gentle downward curve, terminating just in front of the apices of the primary lamellæ and above the bases of the spiral cones; its extremity is broadened and bifurcated, these secondary processes, however, extending but a very short distance. The posterior edges of the lateral branches of the jugum and of the primary lamellæ may be finely fimbriated.

There is usually no trace of a median septum in this valve, but occasionally an obscure ridge is preserved. No muscular markings have been observed.

The external surface is covered with numerous fine radiating striae, which are rarely crossed by concentric lines. Shell-substance richly punctate.

Type, *Retzia vera*, Hall. Kaskaskia limestone.

Distribution. Lower—upper (?) Carboniferous.

(?) *Acambona*, White. 1862.

(Plate 37, figs. 21, 22.)

Shells similar to *EUMETRIA*. Beak of pedicle-valve prominent, incurved, pointed (?). Deltarium triangular or flat. Brachial valve without the alate cardinal extensions of *EUMETRIA*. Internal pedicle-tube slightly developed. Hinge-plate with two short processes on its posterior edge which extend for only a short distance into the umbonal cavity.

Type, *Acambona prima*, White. Burlington limestone.

Distribution. Lower Carboniferous.

Hustedia, Hall. 1893.

(Plate 37, figs. 13-20.)

Shells distinguished externally from *EUMETRIA* by their much coarser plications. The essential difference from that genus lies in the structure of the hinge-plate and the umbonal cavity of the pedicle-valve. The latter contains an internal tube attached by one side to the deltarium and split along the opposite side, a precisely similar structure to that observed in *RETZIA* and *ACAMBONA*, though not so highly developed as in the first of these. The hinge-plate is constituted as follows: It is erect and recurved into the umbonal cavity of the pedicle-valve, projecting considerably beyond the hinge-line; the upper face is convex and elevated medially, the posterior margin sinuate and crescentic, though the horns of the crescent are very short; two deep converging grooves pass over the upper face, and outside of these on the lateral margin of the plate are strong lobes which bear the erect, slightly recurved crura; from the crural bases the lateral margins curve downward to the bottom of the valve and form the socket walls. At the base of the cardinal process and in the median line arises a free, slender, ligulate process which curves upward and back-



FIGS. 366-368. — Outline profile of *Hustedia Morroni*, Marcou (sp.), with enlarged transverse sections of the umbo beneath the foramen; showing the internal tube adherent to the coalesced deltidial plates.

ward with a somewhat less curvature than the plate and rises to the highest point attained by the latter; the inner surface of this process is deeply grooved and at its base it is supported by a



FIG. 369.—Jugum of *Hustedia Mormoni*, Marcou (sp.).

median septum which extends for one-third the length of the valve. There is no tent-shaped structure for the support of the crura as in *EUMETRIA*.

The spirals have the same structure as in *EUMETRIA*, and the posterior margins of the coils are fimbriated. The jugum, also, is quite similar to that of *Eumetria Verneuiliana*, terminating in a long, sharp, retrally directed stem, the posterior edges of the lamellæ both of the stem and the lateral branches being furnished with divergent spinules. The extremity of the stem appears to be simple.

Shell strongly punctate.

Type, *Hustedia Mormoni*, Marcou (sp.).

Distribution. Coal measures.

Trematospira, Hall. 1859.

(Plate 38, figs. 1-12.)

Shells transverse, subequally convex, with median fold and sinus on brachial and pedicle-valves respectively. Surface covered with radial, coarse or fine, simple or duplicate plications. Hinge-line straight, often long; cardinal extremities abruptly rounded; anterior margin sinuate. Umbo of the pedicle-valve incurved, its apex truncated by a circular foramen. Beneath it lies the delthyrium, which is covered by two short incurved plates, more or less closely anchylosed along the median suture, and so greatly thickened on their interior surface as to appear continuous with the substance of the valve.

The deltarium does not extend downward much more than one-half the distance from the apex to the cardinal margin, leaving beneath it a crescentic opening which is occupied by the beak of the opposite valve. On either side of the deltarium is a narrow

and rather abrupt flattening of the shell, suggestive of a cardinal area. The umbonal cavity is short and usually much thickened, leaving only a simple passage for the pedicle. The teeth are approximate and prominent, arising from the bottom of the valve, and above the hinge-line curved backward and toward each other, making a very close and firm articulation with the other valve. The dental lamellæ are not continued over the interior of the valve. The muscular area is well defined and consists of a deep posterior area, in front of which lies a flabelliform scar, extending for fully one-half the length of the shell.

In the brachial valve the beak is not prominent and the false area is absent. A small chilidium is present and lies against the vertical posterior wall of the hinge-plate. The hinge-plate is greatly elevated; it rests upon two stout supports which are placed very closely together, leaving no opening between them at the bottom of the valve. The upper face of the plate is quadrate, but very deeply divided by a median longitudinal groove, and less conspicuously by a transverse groove; the surface is thus divided into four parts, two posterior portions which extend backward into the umbonal cavity of the opposite valve, as short, stout horns, and two anterior processes which are broader but equally elevated; from the ante-lateral margins of the latter arise the crura. In the deep, longitudinal cleft or groove of the plate is a short, convex lobe, terminating posteriorly in a simple or double extremity; sometimes this part is absent. The whole process is rendered more prominent by being slightly constricted about its base. It is supported interiorly by a short median septum, which is frequently obsolete. The dental sockets are small and deep. The crura are broad, thin and comparatively short, and unite with the primary lamellæ in a sharp lateral curve without diminution or increase in size. The umbonal blades are not greatly incurved and are quite as narrow as any portion of the primary ribbon. The jugum takes its origin well forward near the middle of the spiral cones; the lateral branches are somewhat broadened at their origin, but become slightly constricted and twisted just above their bases,

and then widen again, attaining their greatest width where they unite. From their line of union there is a short, acute

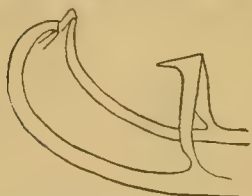


FIG. 370.—Jugum of *Trematospira multistriata*, Hall.

and simple process extended horizontally backward. The attitude of the jugum is erect, at its base extending slightly backward and then curving broadly forward and upward; in height, it reaches rather more than half-way across the bases of the spiral cones. The cones are situated as in allied genera and the ribbon, in mature shells, makes nine or ten volutions. Muscular impressions indistinct. Shell substance punctate.

Type, *Trematospira multistriata*, Hall. Lower Helderberg group.

Distribution. Upper Silurian — Devonian.

Parazyga, Hall. 1893.

(Plate 38, figs. 13–20.)

Shells similar in general external aspect to *TREMATOSPIRA*. The surface markings consist of numerous fine, rounded, simple ribs, extending alike over median fold and sinus, and these are covered with exceedingly fine, short, hair-like spines, which are usually broken off, leaving only their bases.

The umbo of the pedicle-valve is closely incurved and the deltarium (or coalesced deltidial plates) which is entirely concealed by the umbo of the opposite valve, is usually lost. The apical portion of the umbonal cavity bears an introverted lamella which forms an incomplete tube like that in *RETZIA*, *HUSTEDIA*, etc., but of no great extent. The teeth are as in *TREMATOSPIRA* and are supported by stout plates. The muscular area is short, rather well defined, and is divided into a broad central adductor impression, along the lateral margins of which lie two flabellate diductor scars.

The hinge-plate is very narrow, and is composed of two vertical supports which have their origin on the downward umbonal slope of the shell. These supports are widely separated at their bases and enclose the marginal dental sockets; their anterior

faces are vertical and their upper surfaces small and subtriangular. They do not unite with each other at any point, but each is curved slightly back of the cardinal line, and on its ante-lateral angle supports a crus. The jugum is situated at about the center of the primary lamellæ, bends backward for a short distance, and then forward at an abrupt angle. Beyond this angulation its length is about twice that before it. It terminates as in



FIG. 371. Jugum of *Parazyga hirsuta*, Hall.

TREMATOSPIRA, in a short, sharp and simple horizontal process directed posteriorly.

Type, *Parazyga hirsuta*, Hall. Hamilton group.

Distribution. Devonian.

Anoplothea, Sandberger. 1855.

(Plate 39, figs. 1-8.)

Synonym; *Bifida*, Davidson, 1882.

Shells small, oval, concavo-convex; surface with a few sparse, coarse plications, crossed by fine, often imbricating, concentric lines. Pedicle-valve with a conspicuously arched dorsum; brachial valve with a distinct median depression. On the interior of the pedicle-valve the teeth are large and stout, artic-



FIG. 372.



FIG. 373.

The brachidium of *Anoplothea lepida*, Goldfuss (sp.).

FIG. 372.—A lateral view, showing the relations of the jugum to the median septum and ridge.

FIG. 373. A posterior view.

ulating in deep sockets on either side of a broad, thickened, slightly elevated hinge-plate. The volutions of the spirals are few and the cones are directed toward the lateral slopes of the pedicle-valve. The jugum arises at about the half-length of the primary lamellæ, the lateral branches uniting near the center of the internal cavity and forming a simple upright stem whose extremity is fitted into a longitudinally grooved callous in the pedicle-valve. In the brachial valve is a strong median septum

reaching for nearly the entire length of the valve and rising vertically, beneath the lateral jugal processes, almost to the jugal angle.

Shell substance fibrous, impunctate.

Type, *Anoplothea venusta*, Schnur (sp.).

Distribution. Middle Devonian (Eifel and Torquay).

Subgenus *Cœlospira*, Hall. 1863.

(Plate 39, figs. 8-17.)

Shells concavo-convex, oval or circular, with coarse or fine radial, simple or compound plications. The pedicle-valve has distant teeth arising from the lateral cardinal slopes, and in front of the umbonal cavity are a pair of rather deep oval diductor scars, which embrace the anterior extremities of two narrow, less excavated adductors. These are separated by a narrow, more or less conspicuously developed median ridge.

The cardinal process has the same structure as in *ANOPLOTHECA*, consisting of a central portion curved backward to, or slightly beyond the hinge and faintly bilobed on its posterior extremity. The crural bases are consolidated with the central process and are continuous with the socket walls. There is a stout median ridge dividing the muscular impressions and supporting the cardinal process.

The crura are slender and rather long, slightly converging toward their apices, forming an acute angle where they meet the primary lamellæ, the latter turning outward and backward and remaining widely separated throughout their extent. The coil is lax, the ribbon making but about three volutions, and the cones, though very slightly elevated, have their apices directed outward, toward the lateral slopes of the pedicle-valve. The shells vary considerably in convexity both naturally and from accidental compression, and where the internal cavity is shallow the spirals may appear to be coiled almost in a plane.

The umbonal curves of the primary lamellæ are very broad and stout; the jugum arises on their posterior limb, is broad and strong, its lateral processes curving gently forward and thence upward, being elevated and acutely angulated at the apex.

Beyond the junction of the lateral processes the jugum is continued as a simple stem which is inclined backward and may

have been extended to the surface of the internal ridge on the pedicle-valve.

In front of the base of the jugum the primary lamellæ become at once narrow and delicate, and it not infrequently happens, in

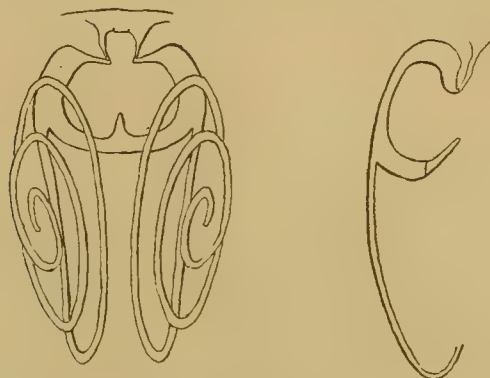


FIG. 374.—The brachidium of *Cælospira concava*, Hall.

FIG. 375.—Profile, showing the elevation of the jugum. The stem of the jugum is probably broken and, therefore, shorter than is natural.

preparations of the interior, that the more fragile portions of the ribbon are lost, leaving only the umbonal blades and the jugum.

(Type, *Cælospira concava*, Hall. Upper Silurian (Clinton group)—Middle Devonian.)

Subgenus **Leptocœlia**, Hall. 1859.

(Plate 39, figs. 18–27.)

Shells similar to *CÆLOSPIRA* in general contour, structure of hinge, cardinal process, muscular scars and internal septa, though of larger size and coarser plication. In the original diagnosis of *LEPTOCÆLIA* the shell was described and figured as possessing a terebratuloid loop. It was, however, distinctly stated that the evidence of this structure was confined to a single specimen containing cavities in its filling of quartz, which corresponded to the restoration given. Subsequent investigations have not corroborated this observation.

Specimens are not often favorably preserved for the retention of the brachial apparatus, those from Cumberland, Maryland, being replaced by silica and often filled with coarsely crystallized quartz, while those from New York, Gaspé and South American localities are usually in the form of casts in an arenaceous sedi-

ment. No trace of the loop has been found, and it is highly improbable that a species agreeing in all known points of structure with the spirigerous groups just discussed and having also a fibrous shell should possess such a structure.

(Type, *Leptocælia flabellites*, Conrad (sp.). Lower Devonian; New York, New Brunswick, Brazil, Bolivia, South Africa).

Vitulina, Hall. 1860.

(Plate 39, figs. 28-36.)

Shell of rather small size; plano-convex in contour, transverse, the hinge-line making the greatest diameter of the valves. The pedicle-valve is convex, its umbo scarcely elevated and its apex not prominent or incurved. A cardinal area is highly developed, and is divided medially by an open, triangular delthyrium, which bears no traces of deltidial plates in any condition that has been observed. The delthyrium is very wide, its base covering more than one-third the extent of the hinge-line. The teeth are blunt, thickened, and not supported by dental plates. The scar of the pedicle-muscle is distinctly defined, but those of the other muscles are obscure in their limitation. Under the most favorable preservation, there appears a posterior pair, flabellate in form, situated just in front of the pedicle-scar, and, more anteriorly, a median scar enclosed by two anterior diductor impressions. There is, at times, a low median ridge, which is purely muscular in its origin.

The brachial valve is depressed-convex or flat; it bears a narrow cardinal area coextensive with that on the opposite valve. The delthyrium is wide and open, and when the conjoined valves are viewed from behind, the cardinal process and socket-walls are clearly seen through the wide pedicle-passage. The former of these, the cardinal process, is a straight, simple apophysis, like that in *ANOPLOTHECA* and *CÆLOSPIRA*; and the socket walls, which are also the bases of the crura, are short, but prominent and elevated, bordering deep and narrow dental sockets. The brachidium consists of loosely coiled spirals of about four volutions, the cones having their apices directed toward the lateral margins of the valves. On the dorsal side the primary lamellæ are close together, but, on the ventral side, they are wide apart, this fact indicating that the bases of the spirals do not lie in parallel planes but converge toward the brachial valve, so that

the slope of the cones, which are somewhat appressed laterally, is essentially that of the lateral slopes of the pedicle-valve. The character of the jugum has not been ascertained. The muscular impressions consist of four distinct adductor scars which are separated medially by a low, thin ridge.

Surface of both valves covered by a few coarse plications, continuous from the umbones to the margins. Of these there are four or five on the lateral slopes. On the pedicle-valve the median pair is the strongest, and forms a sort of double fold with a low sinus between them. On the brachial valve there is a corresponding low median sinus, which contains a simple or double plication. The exterior is covered with fine elevated radiating lines which are usually interrupted to form radiating rows of elongate, lachrymiform pustules.

Shell substance fibrous, impunctate.

Type, *Vitulina pustulosa*, Hall.

Distribution. Lower and Middle Devonian (New York, Brazil, Bolivia, South Africa).

Anabaia, Clarke. 1893.

Shell allied to *LEPTOCELIA* in the structure of its cardinal process and articulating apparatus, having, however, a highly convex brachial valve with a median septum extending one-half its

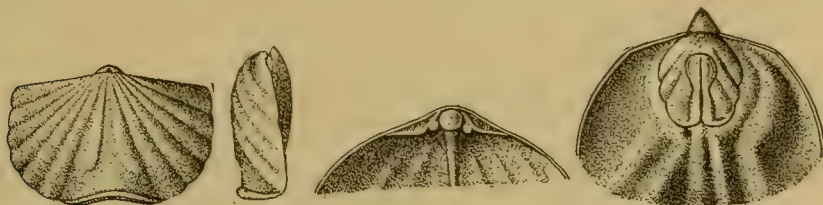


FIG. 376.

FIG. 377.

FIG. 378.

FIG. 379.

Figs. 376-379.—*Anabaia Paraia*, Clarke.

Fig. 376.—Exterior, showing the brachial valve.

Fig. 377.—Profile of a somewhat compressed specimen.

Fig. 378.—Interior of the brachial valve; showing the cardinal process, crura, dental sockets and septum.

Fig. 379.—Internal cast of portion of the pedicle-valve; showing the muscular scars.

length, two short, abruptly ending plications on the low median fold, upturned anterior margins, and explanate cardinal extremities.

Type, *Anabaia Paraia*, Clarke.

Distribution. Upper Silurian (Amazonas).

Nucleospira, Hall. 1859.

(Plate 38, figs. 21-38.)

Shells usually small; subcircular in outline. Valves subequally convex, often gibbous or ventricose. Hinge-line very short, cardinal extremities rounded. On the pedicle-valve the cardinal area is low and obscured by the incurvature of the beak. Only in very young specimens is the deltidium

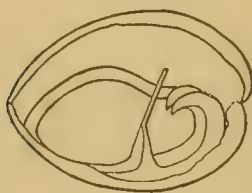


FIG. 380.



FIG. 381.



FIG. 382.

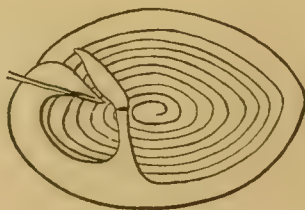


FIG. 383.

FIG. 380.—A preparation of *Nucleospira ventricosa*, Hall; showing the umbonal blades, the jugum and the form of the first volution of the spirals.

FIGS. 381, 382.—The primary lamellæ and jugum of *Nucleospira ventricosa*, Hall.

FIG. 383.—A preparation of *Nucleospira concinna*, Hall; showing one-half of the brachidium, the mode of attachment of the crura to the umbonal blades and the flattened stem of the jugum.

exposed, and it then consists of two plates attached to the lateral margins of the delthyrium; in mature individuals these plates are coalesced and incurved, the median suture is lost and the foramen covered; the appearance of the deltidium is that of a triangular concave plate, limited by rather sharp dental ridges and covering the delthyrium for about half its length. The teeth are prominent, approximate, recurved at the tips, supported by thickened bases but not by lamellæ. Dental sockets very

narrow. The muscular area is flabellate and extends for nearly one-half the length of the shell; it is composed of two elongate-ovate adductor scars inclosed by broad and radially striated diductors. A conspicuous median septum begins in the umbonal region and extends to within a very short distance of the anterior edge of the valve.

In the brachial valve the hinge-plate arises from the bottom of the shell with a vertical anterior face; but just above the plane of the margins of the valve it is reflected in a curve so abrupt that its upper face becomes horizontal. The anterior face is concave and quadrate in outline; the posterior face is subtriangular, flat or concave, and is frequently bilobed at its extremity. In profile the plate has a hook-shaped appearance, and its posterior extremity is elevated considerably above the beak of the valve, and when the valves are in articulation, extending quite to the bottom of the umbonal cavity of the pedicle-valve. The crural bases are situated on the vertical face of the plate, just at the point of recurvature. The crura are slender, straight, long and rod-like, having a length equal to fully one-fourth that of the shell. They are attached at their tips to the inner surfaces of the primary lamellæ. The primary lamellæ of the spiral coils are greatly incurved and their apices close together; their umbonal blades are very broad. The jugum originates at about one-fourth the length of the lamellæ, is inclined slightly backward, the lateral branches uniting directly in front of the apices of the lamellæ, and forming a single straight stem, which is continued beyond the opposite edge of the coil and almost to the inner surface of the pedicle-valve. The spiral ribbon makes from six to ten volutions, and the cones have their altitude in the transverse diameter of the shell.

The muscular area is very narrow and elongate, the posterior adductor scars enveloping the extremities of the anterior adductors. They are divided into pairs by a median septum of the same extent as that of the pedicle-valve. Fine racemose vascular sinuses are sometimes retained over the pallial region of both valves.

The external surface usually bears a low median sinus and fold on the pedicle-, and brachial valves respectively. The epidermal

layer of the shell is usually, probably always, covered with numerous fine, short spinules; these, when removed, leave the surface with only regularly concentric growth-lines, marked by papillæ which are the bases of the spinules.

Type, *Spirifera ventricosa*, Hall. Lower Helderberg group.

Distribution. Upper Silurian — Lower Carboniferous.

Cyclospira, Hall. 1893.

(Plate 40, figs. 1-3.)

The type of this genus, *Atrypa bisulcata*, is a subtriangular shell with a very convex pedicle-valve and a depressed brachial valve. The larger valve has a prominent umbo, the beak being closely incurved over the hinge, concealing both foramen and deltidium. The umbo is longitudinally keeled, but at about one-

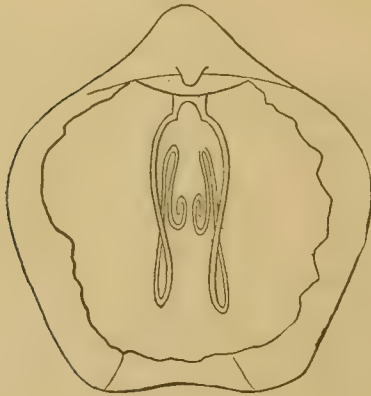


FIG. 334.



FIG. 385.

The brachidium of *Cyclospira bisulcata*, Emmons (sp.).

third the length of the valve a median furrow begins on this ridge, widening anteriorly, and thus making a double keel over the forward parts of the shell. The lateral slopes are broad and smooth, interrupted only in the umbo-lateral regions by a short fold on each side, originating at the beak and lying just within the margins.

The brachial valve is slightly convex posteriorly, becoming concave medially over the pallial region. The median sinus

bears a low fold corresponding to the central groove of the opposite valve. On the interior of the pedicle-valve the shell in the umbonal region is very thick, and in this thickened portion the scar of the pedicle-muscle, and in front of it, the adductor scar is excavated. At the anterior edge of the muscular area the shell becomes suddenly and abruptly thinner, and thus that area lies on a well-developed, solid platform. In the brachial valve the hinge-plate is small and supported by a low median septum which extends about two-thirds the length of the valve.

The crura diverge slightly as they pass downward, making a very low curve or slight angulation at their union with the primary lamellæ. The spiral ribbon is very delicate and quite short, making but two and one-half or three volutions, which are almost circular. These spirals are coiled in planes nearly parallel to the vertical axial plane of the shell, being very slightly introverted, and the primary whorls so close together that this slight introversion brings the apices into approximation. There is as yet no satisfactory proof of the existence of a jugum; indeed, the evidence derived from a number of transparent preparations is decidedly negative upon this point. Where the crura are attached to the primary lamellæ, the ribbon is broadened, and just in front of these points there appear to have been two short convergent apophyses which may be construed as discrete elements of a jugum, but the shell appears to have been actually ajugate.

Subgenus *Protozyga*, Hall. 1893.

(Plate 40, figs. 4, 5.)

Shells small, subplano-convex, the pedicle-valve being the deeper. The ante-lateral margins of the valve bear evidence of broad, coarse plications.

The brachial valve has a simply divided hinge-plate, upon these divisions resting the two short convergent crura; joining the latter at a low angle, the primary lamellæ diverge laterally, converge slightly toward their anterior margins, thence curve vertically upward, nearly touching the inner surface of the pedicle-valve and very gradually approaching each other. The ribbon is continued with a decided internal inclination, until it completes

slightly more than one entire volution. Toward the anterior margins of the primary lamellæ a strong jugum is given off, its lateral branches projected very obliquely backward, sometimes scarcely rising between the coils, the union forming a broad angle

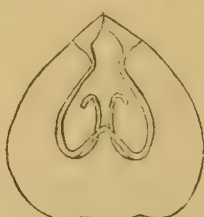


FIG. 386.



FIG. 387.

The brachidium of *Protozyga exigua*, Hall.

on the anterior margin with a subacute process on the outer margin.

(Type, *Protozyga exigua*, Hall. Lower Silurian (Trenton limestone).)

Hallina, N. H. Winchell and Schuchert. 1892.

(Plate 40, figs. 6-8.)

Shells small, oval in outline; valves biconvex and covered with numerous fine, sharp radial plications. Brachidium consisting of lateral processes making somewhat less than a single volution



FIG. 388.



FIG. 389.



FIG. 390.

Preparations showing the structure of the brachidium in *Hallina Saffordi*, Winchell and Schuchert.

Fig. 388. The pedicle-valve cut so as to show the tips of the ascending lamellæ.

Fig. 389. The opposite side, showing the form of the primary lamellæ as far as the base of the jugum, and the character of the latter.

Fig. 390. View showing the brachidium in profile.

and united by a simple, posteriorly directed jugum, situated near their anterior upward curvature.

Type, *Hallina Saffordi*, N. H. Winchell and Schuchert.

Distribution. Lower Silurian (Trenton limestone.)

Glassia, Davidson. 1881.

(Plate 40, figs. 9-12.)

Shells small, biconvex; elongate-ovate in outline; surface smooth. Umbo of the pedicle-valve not conspicuous; beak depressed. Structure of the deltidium and hinge as in *NUCLEOSPIRA*. Muscular impression consisting of two widely divergent, oval diductor scars, between which lies a broad adductor scar.



Fig. 391 *Glassia obovata*, Sowerby (sp.). Interior of the pedicle-valve.

Brachial valve with an internal septum. The spiral cones have their bases toward the lateral margins of the shell and their apices at the center of the internal cavity; their position with reference to each other is, therefore, just the reverse of that in *MERISTELLA*, *RETZIA*, etc. The cones are laterally compressed, and the ribbon makes but few volutions. The jugum originates as in *ATRYPA*,



FIG. 392. Brachidium of *Glassia obovata*, Sowerby (sp.). (DAVIDSON.)

is continuous, bending downward into the space between the cones and making a sharp angle at the point of union, which may be directed upward.

Type, *Glassia obovata*, Sowerby (sp.).

Distribution. Lower Silurian — Middle Devonian.

Zygospira, Hall. 1862.Synonym, *Anazyga*, Davidson, 1882.

(Plate 40, figs. 13-25.)

Shells usually small. Outline subcircular or transversely oval. Contour subplano-convex. Surface sharply plicate. Pedicle-valve with a median plicated ridge. Umbo narrow and prominent; beak acute and incurved. Foramen elongate, rarely apical, enclosed by the deltidial plates. Hinge-line long and straight; cardinal extremities rounded. A distinct false area is formed by a pair of ridges diverging from the beak toward the

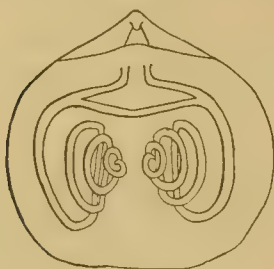


FIG. 393.

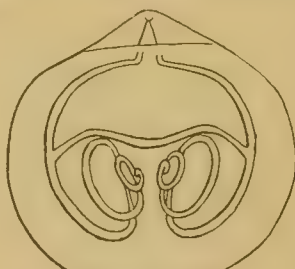


FIG. 394.

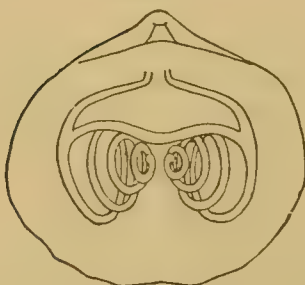


FIG. 395.

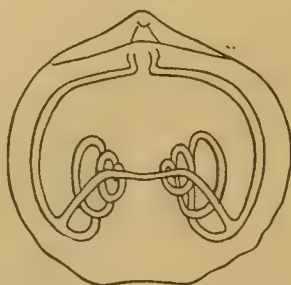


FIG. 396.

Preparations of *Zygospira modesta*, (Say) Hall; showing the variation in position of the jugum.

cardinal extremities. On the interior the teeth are moderately well developed and unsupported by dental lamellæ.

The brachial valve is depressed convex in the umbonal region and bears a more or less conspicuous median sinus. The hinge-plate consists of two broad, stout processes, diverging outwardly, grooved on their summits, and separated from each other by a narrow, sharp cleft. They form both the socket walls and crural bases, and are supported by a low median ridge. Muscular impressions obscure in the typical species.

The crura are short and straight at their union with the primary lamellæ, making a rectangular curve. The first half-

volution of the ribbon lies just within the margins of the valves, and the number of volutions is small. The spirals have their bases parallel to the lateral slopes of the pedicle-valve and their apices directed obliquely toward the center of the opposite valve. The jugum is a continuous band, variable in position and shape. It may originate on the posterior or anterior limb of the primary lamellæ, or be placed medially; its apex is always angular and directed anteriorly and the lateral curves vary in length and degree according to their position with reference to the spirals.

Type, *Zygospira modesta*, (Say) Hall. Hudson River group.

Distribution. Lower — Upper Silurian.

Subgenus *Catazyga*, Hall. 1893.

(Plate 40. figs. 26-33.)

Shells rather large, subcircular or ovoid, with valves more convex than in *ZYGOSPIRA*, the rotundity of the pedicle-valve obscuring the usual prominence of the umbo in that genus. Both valves bear a low median sinus, while the external surface, instead of being coarsely plicated as in *ZYGOSPIRA*, is covered with a great number of fine radiating striæ. The typical external expression of *ZYGOSPIRA* is thus to a large degree lost. On the interior of the pedicle-valve the muscular impressions are well defined; the pedicle-cavity is deep, and in front of it lies a more deeply excavated, short, sharply defined and longitudinally striated impression. In the brachial valve is a broad anterior and a narrow, elongate posterior pair of scars. The spirals are of essentially the same character as in *Z. modesta*, though the form of the cones is such that their apices converge toward the median line in a plane just below the surface of the brachial valve. The jugum, however, differs; it is, in the first place, persistently posterior in its position, originating as in *ATRYPA*, the lateral lamellæ bending downward toward the bottom of the brachial-valve and directed forward in lines which are parallel for a short distance. Thence they bend inward and upward, meeting in a short angle in the space just behind the apices of the spirals.

(Type, *Catazyga Headi*, Billings (sp.). Lower and Middle Silurian.)



FIG 397.—Preparation of *Catazyga Headi*, Billings (sp.); showing the form of the spiral cones and jugum as viewed from the brachial valve.

Subgenus *Orthonomæa*, Hall. 1850.

(Plate 40, figs. 34-37).

Large shells, having the contour of *ZYGOSPIRA*, but with extremely fine surface plications.

(Type, *Orthonomæa erratica*, Hall. Hudson River group.)

Clintonella, Hall. 1893.

(Plate 40, figs. 38-44.)

Shells usually small, suboval in outline; valves subequally biconvex, the axis of greatest convexity being oblique, making an angle of about fifty-five degrees with the vertical axis of the shell. Pedicle-valve with a small umbo, which is compressed laterally, the apex being slightly incurved. The cardinal area is replaced by a wide triangular delthyrium, which is unaccompanied by any trace of deltidial plates. The medially elevated umbo merges anteriorly into a sinus which makes a deep flexure at the margin; it bears two plications, both of which reach the beak; sometimes a trace of a third plication may be seen. The lateral slopes bear from four to eight radial plications of smaller size.

On the interior the teeth are prominent, strongly recurved at their tips and supported by lamellæ which terminate abruptly. The lower and inner margins of these lamellæ are thickened, contracting the pedicle cavity, which is, consequently, narrow and deep. The diductor scars are of moderate size, flabellate in outline and deeply impressed at their posterior extremity. They are crossed by traces of the radial surface plications. Between them lie the narrow obovate adductor scars.

In the brachial valve the beak is inconspicuous; the umbonal region depressed for about one-third the length of the shell, thence anteriorly becoming developed into a median fold. The greatest convexity of the valve is attained in front of the center. The cardinal margin is scarcely thickened; the dental sockets quite narrow. The hinge-plate consists of two flattened processes, inclined toward each other and closely approximate along their inner bases, though not meeting. Each process is divided into an anterior and posterior lobe, the latter being the smaller and resting upon the former. These anterior lobes are narrow

and slender, and constitute the crural bases. Spirals are present, but their direction and the nature of the loop are undetermined. A stout median ridge supports the hinge-plate and divides the scars of the adductor muscles. In both valves the lateral portion of the umbonal region is pitted. The plications of the surface are covered by fine, sharp and elevated concentric striæ. Shell substance, fibrous, impunctate.

Type, *Clintonella vagabunda*, Hall.

Distribution. Upper Silurian (Clinton group).

Atrypina, Hall. 1893.

(Plate 41, figs. 1-6.)

Shell small, subovate or subcircular in marginal outline, plano-, or subconcavo-convex in contour; surface coarsely and sparsely plicated.

Pedicle-valve with the umbo prominent, the beak abruptly acute and more or less incurved. Foramen apical, and deltidial plates normally developed. The cardinal margins of the valve are somewhat extended in the typical species, though the hinge itself is quite short. Teeth divergent and unsupported, taking their origin on the lateral cardinal slopes, and very slightly recurved. Muscular scars exceedingly faint; no internal septa observable.

Brachial valve with the cardinal process small, consisting of two short lobes, which meet at their apices, not extending back of the hinge-line, and diverging anteriorly. The surface of each lobe may be longitudinally grooved, but the inner and outer divisions thus formed are confluent at their outer extremities. The anterior face of the process is abrupt and vertical, its lower portion being continuous with the socket walls. In front of the cardinal process, but not supporting it, is a low median ridge, on either side of which are obscure muscular imprints. The brachial apparatus consists of introverted spirals whose bases lie against the lateral slopes of the pedicle-valve and whose apices are directed toward the center of the brachial valve. The ribbon is loosely coiled and makes



FIG. 398.—The brachidium of *Atrypina disparilis*, Hall.

but three or four volutions. The jugum is situated posteriorly and constructed as in *ATRYPA*, except that its lateral lamellæ appear to be always united in an acute angle, which is directed inward.

Muscular impression composed of large flabellate diductors, enclosing distinct adductor scars.

Type, *Atrypina imbricata*, Hall.

Distribution. Upper Silurian — Devonian.

***Atrypa*, Dalman 1828.**

(Plate 41, figs. 7-17.)

Shell subcircular or longitudinally suboval in outline. Gibbous, strongly inequivalve. Hinge-line short, straight; cardinal extremities rounded. Beaks not prominent.

Pedicle-valve the smaller; convex in the umbonal region, but depressed and often deeply sinuate anteriorly. Beak small, usually incurved in advanced growth-stages, concealing the foramen and deltidium. The foramen is triangular in young shells, extending to the hinge-line, but becoming gradually closed by the growth of deltidial plates, and at maturity is circular and apical, encroaching slightly on the substance of the valve. The plates of the deltidium are not coalesced along the median suture. On the interior the umbonal cavity is short but very broad. The teeth are large, widely separated and doubly grooved, first by an oblique furrow at the base, into which is fitted a crenulated ridge of the other valve, then by a short longitudinal depression on the summit; the tooth is doubly curved and reflected, making the articulation of the valves very firm. These teeth arise from the inner surface of the lateral slopes of the valve, and are hence unsupported by lamellæ. The muscular impressions are sharply defined; the triangular pedicle-scar is followed in front, by a median elongate double scar of the adductors, outside of which are strong, radiately striate, flabellate diductors, which frequently extend beyond the middle of the valve.

Brachial valve convex or rotund in the middle, with a median fold which is rarely developed except toward the anterior margin. Beak incurved and concealed. No cardinal area. The hinge-plate is composed of two diverging processes which may or may not meet at the apex. Each of these processes is obliquely

grooved, forming an inner and outer lobe. The latter forms the upper portion of the socket-wall which is curved downward and unites with the lateral surface of the valve, forming a broad dental socket which is traversed by an oblique crenulated ridge. The inner lobes of the hinge-plate are short, their extremities free, bearing the crura.

These crura are long and narrow, diverge laterally and are attached to the primary lamellæ near their ante-lateral curvature.

The mode of attachment is peculiar, the crural lamellæ bending upward and then abruptly downward, greatly widening at the line of contact and touching the spiral ribbon only at its outer margin. The demarkation between the crura and the ribbon of



FIG. 399.—Diagram of *Atrypa reticularis*; showing the form and structure of the jugum and the mode of attachment of the crura to the hinge-plate and the primary lamellæ.

the coils is, therefore, very distinct. The spirals have, in a general sense, their bases parallel to the inner surface of the pedicle-valve and the apices directed toward the deepest point of the opposite valve. Their axes are more or less convergent, so that the approximate surfaces of the cones are flattened. The basal section of these cones is hemicordate, the anterior extremity being much the narrower, but the upper volutions are more nearly elliptical. The ribbon is broad, being conspicuously so on the anterior curves of the first few volutions, each one extending considerably beyond the next following. These anterior curves may be more or less distinctly fimbriated. The jugum is composed of two processes which are continuations of the primary lamellæ without angulation. These processes are situated posteriorly, directed toward the center of the shell, and are, in effect, the starting points of the spirals. They have the following structure: The ribbon maintains its usual width for a considerable distance within the point of attachment to the crura, then narrows rather abruptly, the processes ascending as they approach each other. Their terminations in mature shells are broadened, thickened, erect and recurved at the tips, having a clavate appearance. In immature growth-stages or undevel-

oped adult conditions this thickening is absent, the extremities of the processes are in close apposition, or may form a continuous lamella. The muscular impressions consist of four large adductor scars divided by a low median ridge.

Ovarian pittings and vascular sinuses occur over the inner surfaces of both valves. The latter consist of two main trunks, sending two branches posteriorly, and two longer converging branches anteriorly.

External surface covered with radial plications crossed by concentric growth-lines; at the crossing of the two series of lines the external layers of the shell may be produced into broad lamellar expansions or hollow spines.

Shell-substance fibrous, impunctate.

Type, *Atrypa reticularis*, Linné (sp.).

Distribution. Upper Silurian — Lower Carboniferous.

Subgenus *Gruenewaldtia*, Tschernyschew. 1885.

(Plate 41, figs. 21, 22.)

Atrypoid shells having the relative convexity of the valves in *A. reticularis* reversed. Spiral cones with their bases lying against the lateral slopes of the pedicle-valve, the outer face of the cones being thus parallel to, and just within the surface of

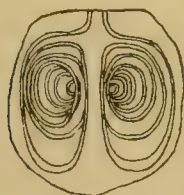


FIG. 400.



FIG. 401.

Spirals of *Gruenewaldtia latilinguis*, Schnur. In fig. 401, the pedicle-valve is the lower and the two median dots represent sections of the primary lamellæ. (TSCHERNYSCHEW.)

the brachial valve. It is such a modification of the brachial apparatus as must necessarily ensue from the variation in the contour of the shell. The character of the jugum has not been determined.

(Type, *Gruenewaldtia latilinguis*, Schnur (sp.). Lower and Middle Devonian.)

Karpinskia, Tschernyschew. 1885.

(Plate 41, figs. 18-20.)

Atrypoid shells with elongate form, radially plicated and subequally convex valves. The spirals have the same positions as in *АТРЫПА*, though the character of the jugum is still unknown. In the pedicle-valve are diverging dental plates, and in the brachial valve a median septum. The vascular trunks are simple and direct, extending to the anterior margin of the valves without branching.

Type, *Karpinskia conjugula*, Tschernyschew. Lower Devonian.

Koninckina, Suess. 1852.

Shell suborbicular, concavo-convex, smooth. Hinge-line straight. Apex of pedicle-valve incurved, beak full. Cardinal area and deltidial plates obsolete at maturity. Spirals double, the principal pair arising from simple crural processes with the extremities of which they made a sharp angle. The jugum is formed



FIGS. 402, 403. *Koninckina*; reconstruction of the brachial apparatus. (BITTNER.)

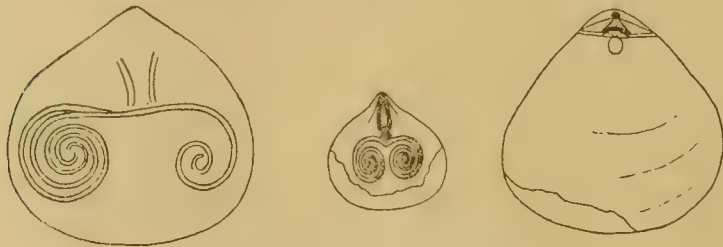
by the anterior extension and union of the crural processes. The accessory spirals are coextensive with the main pair and take their origin from the upper surface of the jugum. The spiral cones are depressed and have their apices directed toward the lateral slopes of the pedicle-valve.

Type, *Koninckina Leonhardi*, Wissman (sp.).

Distribution. Triassic.

Amphiclina, Laube. 1885.

Shell concavo-convex, subtrigonal, with straight hinge-line, well-developed cardinal and deltidial plates. Spirals duplicate, the two pairs being coextensive.



FIGS. 401-406. *Amphiclina dubia*, Münster (sp.).
(FIG. 405, BITTNER; FIGS. 404, 406, BEECHER.)

Type, *Amphiclina dubia*, Münster (sp.).

Distribution. Triassic.

Koninckella, Munier-Chalmas. 1880.

Shell concavo-convex, smooth. Hinge-line straight, cardinal area, deltidial plates and cardinal process well developed. Spirals duplicate, jugum probably as in KONINCKINA. The



FIGS. 407-409. *Koninckella triadica*, Bittner.
(BITTNER.)

volutions of the spiral cones are few, and the ribbon of the primary coils bear long marginal spinules.

Type, *Koninckella liasina*, Bouchard-Chantreaux (sp.).

Distribution. Lias.

Koninckodonta, Bittner. 1893.

Shell as in KONINCKINA but with well-developed cardinal area and deltaria. On the interior of the pedicle-valve is a submarginal row of thickened tubercles which interlock with similar callosities

on the opposite valve subserving to some extent purposes of articulation. Spirals duplicate and echinate; spiral cones depressed.



FIGS. 410, 411.—*Koninckodonta Fuggeri*, Bittner. (BITTNER.)

Type, *Koninckodonta Fuggeri*, Bittner.

Distribution. Triassic.

Thecospira, Zugmayer. 1880.

Shells small, concavo-convex, attached by the umbo of the pedicle-valve. Surface smooth or concentrically rugose; covered with a tubercled periostracum. Shell substance perforate. Cardinal area and deltarium well-developed. In the pedicle-valve the teeth are conspicuous and unsupported; a median septum divides the deeply impressed muscular scars. In the brachial valve the cardinal process is large, elevated, tripartite on the summit, deeply grooved in the middle. Spiral cones double, directed toward the lateral slopes of the pedicle-valve. The



FIGS. 412, 413.—*Thecospira Haidingeri*, Suess (sp.). (ZUGMAYER.)

jugum is a simple arch, broadened at its summit and continued into intercalary lamellæ which are coextensive with the principal coils. The latter are fimbriated on their outer margins.

Type, *Thecospira Haidingeri*, Suess (sp.).

Distribution. Triassic.

Amphiclinodonta, Bittner. 1890.

Shells exteriorly like AMPHICLINA; interiorly articulation is aided by interlocking denticulate callous ridges and tubercles lying



FIG. 414.—*Amphiclinodonta Zugmayeri*, Bittner. (BITTNER).

within the margins of the valves. Structure of the brachidium as in AMPHICLINA.

Type, *Amphiclinodonta Zugmayeri*, Bittner.

Distribution. Triassic.

Rhynchonella, Fischer de Waldheim. 1809.

The number of palæozoic species which have been commonly referred to this genus, and, consequently, regarded as congeneric with the Russian upper Jurassic *R. loxia*, Fischer, the type-species, is very great. To the most conservative student such an agglomeration, presenting every variety of external configuration, must seem more like a hap-hazard and conventional association than a natural group. But it is, nevertheless, evident that features of internal structure, upon the variations in which generic distinctions are usually based, are here most persistent. The crura, hinge apparatus and deltidial structure of *R. loxia* are features which were attained and became fixed in the Silurian period; the extreme pyramidal contour of that species, its smooth surface with few and faint marginal plications, is not, however, except in rare instances, reproduced among the palæozoic forms. What is thus true of the predecessors of *R. loxia* is also, to a large degree at least, true of its living descendants.

From a careful study of the structure of the ancient Rhynchonellas it has become apparent that slight variations from the type of interior possessed by *R. loxia* are frequently of marked con-

tinuance, and we must, therefore, be prepared for closer discriminations in this great group of species than have elsewhere been necessary or advisable, and to emphasize such of these deviations from this stable line of development, as are justified by their persistence and the convenience of classification.

Rhynchonella, sensu stricto.

(Plate 42, figs. 1-3.)

Subpyramidal shells having the margins of the valves sinuous or angulated. Pedicle-valve with a median sinus beginning in front of the convex umbo and, in the type-species, becoming broad and deep, producing a prominent linguiform extension at the anterior margin. Brachial valve convex in the umbonal region and developing anteriorly a prominent median fold. Surface of both valves more or less plicated, often accompanied (as in the type) by fine concentric lines of ornament. The apex of the pedicle-valve is but slightly incurved and exposes a circular or elongate-oval foramen enclosed by the deltidial plates beneath, and above by the substance of the valves. Here is a narrow pseudo-area defined by oblique cardinal ridges diverging from the beak. On the interior the teeth are well developed and are supported by lamellæ which rest on the bottom of the valve near the beak, but are free anteriorly. The muscular area consists of a moderately deep oval scar extending one-third the length of the valve, and composed of two large diductors completely enclosing small central adductors. The posterior surface about the muscular area is pitted with ovarian markings.

In the brachial valve there is no cardinal process; the crural plates are simple, divergent, somewhat expanded on the upper surface but not conjoined except where they converge beneath the beak and meet the median septum, which extends for about one-half the length of the valve. The crura are long and curved upward toward the opposite valve. Muscular area elongate subquadrate, with small posterior and large anterior adductor scars. Shell-structure fibrous.

Type, *Rhynchonella loxia*, Fischer de Waldheim.

Distribution. Jurassic. Cretaceous.

Protorhyncha, Hall. 1893.

(Plate 42, figs. 4-6.)

Shells biconvex, with a low, ill-defined fold and sinus on brachial and pedicle-valves respectively. Pedicle-valve with a false cardinal area defined by ridges diverging from the beak. Pedicle-passage triangular, rarely showing any trace of deltidial plates. Teeth very small, supported by thin lamellæ which rest upon the bottom of the valve and are not adnascent to the lateral walls of the shell. In the brachial valve the dental sockets are small; the hinge-plate consists of two minute discrete processes, the surfaces of which are slightly inclined toward each other. These were the bases of the brachial supports but show no points of attachment to the crura; they are separated by a triangular incision extending to the bottom of the valve. There is no cardinal process nor median septum in the brachial valve, and no trace of muscular scars in either valve.

Type, *Protorhyncha dubia*, Hall. Chazy limestone.

Distribution. Lower Silurian.

Orthorhynchula, Hall. 1893.

(Plate 42, figs. 7-10.)

Shells rhynchonelloid in contour; hinge-line short, straight, extending for about one-third the transverse diameter of the valves. A true cardinal area is present on both valves, that of the pedicle-valve being considerably the broader, erect, often incurved. Each valve also possesses a distinct triangular delthyrium, that of the pedicle-valve, according to the evidence at hand, never being in any degree closed by deltidial plates. External surface strongly and simply plicated, the median fold and sinus being well developed. On the interior, the pedicle-valve possesses blunt teeth which rest upon the laterally thickened walls of the valve and are not supported by lamellæ. Between, and slightly in front of these lies a short, subquadrate muscular scar. The brachial valve possesses a linear cardinal process, on either side of which are two discrete crural plates, sharply concave on the upper surface and diverging anteriorly for a considerable distance.

Shell-substance fibrous, impunctate.

Type, *Orthorhynchula Linneyi*, Nettelroth (sp.).

Distribution. Lower Silurian (Hudson River group).

Rhynchotrema, Hall. 1860.

(Plate 42, figs. 12-16.)

Shells large, thick, often gibbous. In mature conditions the deltidial plates are of great size, thickened and coalesced with the bottom of the valve, their outer surface being concave. The pedicle-passage encroaches upon the substance of the valve, the foramen lying behind the apex and the passage itself inclosed by the thickened deltarium.

The teeth rest upon the thickened lateral walls of the valve, and there appears to have been no development of dental lamellæ unless it was at a very early period in the life of the individual.

In the brachial valve there is a thickened median septum which may extend for more than one-half the length of the shell; and it is upon the posterior extremity of this that the slender median cardinal process rests. This delicate apophysis is frequently distorted to one side or the other. The bases supporting the crura are divided by a very narrow median cleft, and are remarkably broad and stout, abruptly deflected to the deep dental sockets. The crura take their origin from the central portion of this comparatively broad hinge-plate, instead of from the margins of the dental sockets, as is usually the case in the palæozoic rhynchonelloids. The structure of the hinge apophyses in both valves is a persistent character, while the peculiarities of the deltarium are variable with age and external conditions. The muscular impressions are usually strongly developed, there being beneath the deltidial plates a deep scar of the pedicle muscle, while the adductor impression on the pedicle-valve is often very marked. The adductors of the brachial valve and the diductors of the pedicle-valve are more or less distinctly defined.

Type, *Rhynchotrema capax*, Conrad (sp.).

Distribution. Lower Silurian.

Rhynchotrema, Hall. 1879.

(Plate 42, figs. 17-21.)

Trihedral, strongly plicated shells with fold and sinus normal, in adolescent and mature stages; long and broad cardinal slopes; beak erect, acuminate and produced on the pedicle-valve. Foramen at maturity apical, its upper margin encroaching on the

substance of the valve. Deltarium very conspicuous, convex, the component plates, in their later development, being ankylosed along the median suture. Dental lamellæ vertical, resting on the bottom of the valve and inclosing a deeply impressed muscular scar; diductor scars elongate-flabelliform, divided by oblique ridges into anterior and posterior members; adductor impression central, elongate and very small. The brachial valve bears a median septum which extends for one-half the length of the shell, is divided toward its posterior extremity, each branch supporting one process of the divided hinge-plate. The crura are long, slightly curved and somewhat expanded at their tips; between these there is a small, simple, cardinal process.

External surface covered with exceedingly fine, rounded, filiform, concentric lines. Shell-substance fibrous, impunctate.

Type, *Rhynchotreta cuneata*, Dalman (sp.).

Distribution. Lower — Upper Silurian.

Stenoschisma, Conrad. 1839.

(Plate 42, figs. 22-24.)

Subtriangular, coarsely plicate shells; teeth supported by parallel vertical lamellæ; median septum of the brachial valve obscure or absent; median subcardinal cavity such as is found in CAMAROTÆCHIA, wanting, the hinge-plate being divided by a median fissure which extends to the bottom of the shell and contains a slender longitudinal cardinal process; crura long, recurved and expanded at their extremities; surfaces of the dental sockets not crenulated.

Type, *Stenoschisma formosa*, Hall (sp.).

Distribution. Lower Helderberg.

Camarotæchia, Hall. 1892.

(Plate 43, figs. 1-9.)

Shells somewhat variable in exterior though usually maintaining a full trihedral contour with shallow pedicle-, and convex brachial valves, evincing little, if any, evidence of a reversal at maturity of the relative convexity of early growth, a feature apparent in some of the other groups of the rhynchonelloids. The median septum of the brachial valve is divided posteriorly

in such a manner as to form an elongate cavity, which does not extend to the bottom of the valve. Each branch of the septum supports one of the lateral divisions of the hinge-plate, to which are attached the curved crural processes. In normal conditions of development the median interspace of the hinge-plate is not closed. The dental sockets bordering the hinge-plate are crenulated in the typical species. There is no cardinal process.

In the pedicle-valve slender vertical lamellæ support the rather small teeth and extend well into the cavity of the valve, inclosing a deep and narrow pedicle-scar.

Type, *Camarotæchia congregata*, Conrad (sp.).

Distribution. Lower Silurian — Lower Carboniferous.

Subgenus *Plethorhynchus*, Hall. 1893.

(Plate 43, figs. 10-15.)

Large, ponderous and ventricose shells in which the lateral parts of the hinge-plate become united, closing the triangular septal cavity but forming no cardinal process. Dental lamellæ faint, evident only in young shells; teeth large and stout, resting on the lateral walls of the valve.

(Type, *Plethorhynchus speciosus*, Hall. Oriskany sandstone.)

Subgenus *Liorhynchus*, Hall. 1860.

(Plate 43, figs. 16-24.)

Shells having the plications on median fold and sinus highly developed, but those on the lateral slopes usually faint or obsolete. Internal structure as in *CAMAROTÆCHIA*; adductor scars on the brachial valve forming a narrow, elongate-oval impression divided by the median septum.

(Type, *Liorhynchus quadricostatus*, Vanuxem (sp.). Devonian — Carboniferous.)

Wilsonia (Quenstedt), Kayser. 1871.

(Plate 44, figs. 1-5.)

Shells with subcuboidal or subpentahedral contour, fold and sinus not sharply developed except at the anterior margin, abrupt anterior slope, sharply serrated lateral margins of contact and low surface plications, each of which, on the front of both valves, is marked by a fine median line. Dental plates

coalesced with the lateral walls of the pedicle-valve and the teeth upon the margins of that valve. Hinge-plate small, divided by a shallow incision. Cardinal process absent.

Type, *Wilsonia Wilsoni*, Sowerby (sp.).

Distribution. Upper Silurian — Lower Devonian.

Uncinulus, Bayle. 1878.

(Plate 44; figs. 6-9.)

Synonym; *Uncinulina*, Bayle, 1878.

Shells exteriorly like *WILSONIA*; interiorly with a solid, undivided hinge-plate and a highly developed cardinal process.

Type, *Uncinulus subwilsoni*, d'Orbigny (sp.).

Distribution. Devonian.

Hypothyris, (McCoy) King. 1850.

(Plate 44, figs. 10-13.)

Shells strongly subcuboidal. Teeth usually supported by short vertical lamellæ; hinge-plate quite small and composed of two broad, short lateral processes, which are divided, for a portion of their length only, by a median incision extending to the bottom of the valve but not forming an inceptive spondylium as in *CAMAROTÆCHIA*. Dental plates large. There is but the barest indication of a median septum in the brachial valve. Muscular impressions small and not deep; those of the pedicle-valve making an oval scar continued from the narrow pedicle-cavity; those of the brachial valve being narrow, elongate and extremely obscure. Interior of the pedicle-valve frequently preserving the ovarian pittings and vascular sinuses while the characters are but faintly retained on the brachial valve.

Type, *Hypothyris cuboides*, Sowerby (sp.).

Distribution. Devonian.

Subgenus Pugnax, Hall. 1893.

(Plate 44, figs. 14-25.)

Shells with deep fold and sinus; elevated, and often acuminate on the anterior margin; more or less sharply plicated, the plications usually being simple, those of the fold and sinus the strongest, and those of the lateral slopes often obscure or obsolete. Pedicle-valve shallow; brachial valve deep. Teeth supported by vertical lamellæ; hinge plate similar in structure

to that of *HYPOTHYRIS*; the median septum of the brachial valve is extremely faint when present, but is usually undeveloped. Muscular impressions not large but well defined and clearly subdivided. Vascular sinuses sometimes retained on the pedicle-valve, always obscure on the brachial valve.

(Type, *Pugnax acuminatus*, Martin. Devonian—Carboniferous.)

Eatonia, Hall. 1857.

(Plate 44, figs. 30-40.)

Concavo-convex shells with median fold and sinus, and plicated or radiate-lineate exterior. Anterior margin deeply sinuate. From the beak of the pedicle-valve diverge two lateral cardinal ridges which limit a more or less distinct false area. On the interior the teeth are adnascent to the lateral walls of the valve, all traces of supporting lamellæ being absent. Muscular area large, flabellate and deeply excavated in the substance of the shell. Pedicle-impression broad, traversed medially by a longitudinal groove; diductors extending for about one-half the length of the shell, their outer margins being elevated; they enclose a pair of small central adductor scars whose posterior margins are raised into prominent myophores. The scars are divided by a slight median septum which is continued posteriorly; this septum being often rendered very conspicuous by the growth of the shell about the apophyses of the cardinal process of the opposite valve, and in the extreme cases its development is such that it rises above, and incloses the adductor scars, the latter being excavated in its substance.

In the brachial valve the dental sockets are long and narrow, the cardinal process very large and composed of a stout, erect stem resting upon a rather short median septum, and divided at its summit into two long, divergent, tooth-like branches, whose upper faces extend to the interior surface of the opposite valve; hence their greatest elevation is at their anterior extremities, whence they slope toward the beak of the valve, usually uniting before that point is reached. The surface of attachment of each of these apophyses is medially grooved. Below them, and at the base of the central stem, arise the crura, which are long, straight and slender, with expanded extremities. The muscular scars are clearly defined and consist of a pair of small posterior adductors,

and in front of them a larger pair whose surface is radiately striated, the entire area being elongate-oval. Vascular impressions are occasionally retained in the pedicle-valve.

Type, *Eatonia medialis*, Vanuxem (sp.).

Distribution. Lower Devonian.

Cyclorhina, Hall. 1893.

(Plate 42, figs. 27-31.)

Shells of comparatively large size at maturity, subtriangular in outline; biconvex, the convexity of the brachial valve being the greater. Fold and sinus very broad, and developed in the usual manner, on brachial and pedicle-valves respectively.

On the pedicle-valve the apex is obtuse, not elevated, and is very broadly truncated by a large circular foramen, which, even in the earliest growth-stages observed, is enclosed for fully five-sixths of its periphery by the substance of the valve. The deltidial plates are incipient at maturity and scarcely evident in young shells; the delthyrial margins are extremely divergent. The cardinal line is short but straight, and its extremities are produced on each side to form a short alate process or wing, similar to those in the genus *EUMETRIA*. These extensions occur on both valves, and are very apparent in the younger shells, but become somewhat obscured with the increase of convexity accompanying maturity. On the interior, the teeth are large and blunt, and attached to the lateral walls of the shell, though they also rest upon the thick lamellæ similarly attached except at their anterior margins, and which converge downward to form a deep, broad, transversely striated pedicle-cavity. The thickened lateral margins of this impression are continued anteriorly to about the center of the shell, forming an elongate-quadrate diductor scar which incloses a small oval adductor.

The brachial valve has a convex umbo, showing no evidence of concavity in early stages of growth. Beneath the beak is a very fine, vertical, linear cardinal process which appears to be continuous with an obscure median longitudinal ridge, traversing about one-half the length of the valve. Both of these are frequently involved in the shell-substance and evident only in sections of the shell. The hinge-plate is deeply divided medially, each lateral portion being supported by a deep vertical septum resting on the bottom of the valve. The upper surfaces of the hinge processes

are obliquely concave, the outer and anterior angle being much elevated and the slope thence to the dental sockets abrupt. The crura are attached to the inner margins of these plates, are not curved, but their distal extremities are expanded into spoon-shaped processes which have their concave surfaces toward the brachial valve. There are no thickened muscular scars as in the opposite valve.

The surface is covered with sharply angular, simple plications, most of which begin in the umbonal regions, and the broad fold and sinus may bear as many as from eight to twelve of these. All the plications are crossed by fine, sharp concentric lines of ornamentation, which crenulate the summits of the ridges.

Shell-substance fibrous, impunctate.

Type, *Cyclorhina nobilis*, Hall.

Distribution. Middle Devonian.

Terebratuloida, Waagen. 1883.

Shells oval or rounded, with strongly plicated valves and a high median fold in the brachial, and a corresponding sinus in the pedicle-valve. Beak truncated with a terminal round foramen; deltidial plates distinct.

Teeth strong, not supported by dental plates. Brachial valve with a tolerably large triangular hinge-plate, which is triangularly

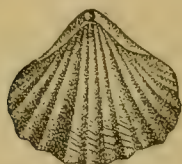


FIG. 415.



FIG. 416.



FIG. 417.

Terebratuloida Davidsoni, Waagen.

FIG. 415.—View of the exterior.

FIG. 416.—Interior of the pedicle-valve.

FIG. 417.—Interior of the brachial valve.

(WAAGEN.)

divided. There is no cardinal process. On both sides of the median incision very short curved crura take their origin, and proceed for a short distance in a slightly diverging direction toward the interior of the shell. There is no median septum in the brachial valve.

Type, *Terebratuloida Davidsoni*, Waagen.

Distribution. Carboniferous—Permian.

Rhynchopora, King. 1856.

(Plate 44, figs. 26-29.)

Synonym; *Rhynchoporina*, Ehlert, 1887.

Plicate rhynchonellids with punctate shell substance. Teeth supported by conspicuous lamellæ; hinge-plate medially divided and without cardinal process.

Type, *Rhynchopora Geinitziana*, de Verneuil (sp.).*Distribution.* Carboniferous — Permian.**Halorella, Bittner. 1890.**

Rhynchonellids with median depression on both valves, sharply defined false cardinal area, and depressed, subauriculate cardinal extremities.

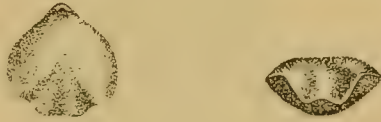
FIGS. 418-420.—*Halorella amphitoma*, Bronn (sp.). (BITTNER.)Type, *Halorella amphitoma*, Bronn (sp.).*Distribution.* Triassic.**Austriella, Bittner. 1890.**

Rhynchonellids of small size with smooth shells, sometimes faintly plicated about the margins.

FIG. 421-424.—*Austriella dilatata*, Suess (sp.). (BITTNER.)Type, *Austriella dilatata*, Suess (sp.).*Distribution.* Triassic.

Norella, Bittner. 1890.

Small, smooth rhynchonellids, with conspicuous median fold and sinus, and sloping hinge-line. Interior unknown.



FIGS. 425, 426.—*Norella refractifrons*, Bittner. (BITTNER.)

Type, *Norella sellaris*, Laube (sp.).

Distribution. Triassic.

Rhynchonellina, Gemellaro. 1871.

Shells transverse, unequally convex, the pedicle-valve being the deeper. Cardinal margin nearly straight. Beak incurved, beneath it lying a concave triangular area, bearing an incipient deltarium. Crura long, curved toward the pedicle valve, their



FIG. 427.—*Rhynchonellina Suessi*, Gemellaro. (GEMELLARO.)

extremities nearly touching that valve. Near their bases these crura give off short jugal apophyses.

Type, *Rhynchonellina Suessi*, Gemellaro.

Distribution. Jurassic.

Dimerella, Zittel. 1870.

Shells small, scenidiiform, with high ventral umbo and a straight hinge-line which equals the full diameter of the valves. Surface plicate. Pedicle-passage large; deltidial plates feebly developed. Brachial valve with an elevated median septum

dividing the interior shell cavity into two chambers. Crural processes long and recurved. Shell substance impunctate.



FIGS. 428-433.—*Dimerella Gumbeli*, Zittel. (BITTNER and ZITTEL.)

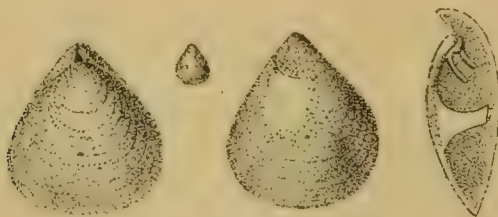
Type, *Dimerella Gumbeli*, Zittel.

Distribution. Triassic.

Cryptopora, Jeffreys. 1869.

Synonyms; *Atretia*, Jeffreys, 1870; *Neatretia*, Ehlert, 1891.

Diminutive shells with a subtriangular contour. Beak prominent and acute; pedicle-passage large, triangular and without deltidial plates. Interior of pedicle-valve with prominent dental



FIGS. 434-437.—*Cryptopora gnomon*, Jeffreys. (DAVIDSON).

plates; brachial valve with a short, but greatly elevated median septum.

Type, *Cryptopora gnomon*, Jeffreys.

Distribution. Recent.

Peregrinella, Ehlert. 1887.

Shells of large size, pedicle-valve the more convex. Valves without median fold and sinus. Margins even; surface plicate.



FIGS. 438, 439.—*Peregrinella multicastrata*, Lamarck (sp.). (QUENSTEDT.)

Beak short, scarcely prominent; cardinal area and deltarium well developed.

Type, *Peregrinella multicastrata*, Lamarck (sp.).

Distribution. Cretaceous.

Hemithyris, D'Orbigny. 1847.

Shells smooth or faintly plicate; median fold and sinus obscure. Beak high, with large triangular pedicle-passage and very slightly developed deltidial plates. Teeth prominent; dental plates absent. Hinge-plate divided medially, but without

forming an umbonal pit. Cardinal process represented by two faint processes beneath the beak.



FIGS. 440, 441.—*Hemithyris psittacea*, Gmelin (sp.) *a*, pedicle-valve; *b*, brachial valve; *c*, posterior adductors; *d*, anterior adductors; *e*, diductors; *f*, pedicle muscles. (DAVIDSON)

Type, *Hemithyris psittacea*, Gmelin (sp.). (Recent.)

Distribution. Tertiary (?)—Recent.

Acanthothyris, D'Orbigny. 1850.

Shells like *HEMITHYRIS*, but having the surface covered with spines, and the dental plates well developed.



FIG. 442.—*Acanthothyris spinosa*, Schlotheim (sp.). (WOODWARD.)

Type, *Acanthothyris spinosa*, Schlotheim (sp.). (Jurassic.)

Distribution. Jurassic—Recent.

Syntrophia, Hall. 1893.

(Plate 45, figs. 1-3.)

Shells transversely elongate, biconvex, with straight hinge-line whose length nearly equals the greatest diameter of the valves; each valve medially divided by an open delthyrium. External surface smooth, with fine concentric lines visible only about the margins; the inner shell-layers show a strongly fibrous radiating structure without punctation. The pedicle valve bears a more or less clearly developed median sinus and the brachial valve a broad, indistinct fold.

On the interior the teeth are very small, lying at the extremities of the delthyrial margins and supported by dental plates

which converge and unite before reaching the bottom of the valve. Thus is formed a deep but short spondylium, which is supported, near its apical portion, by a median septum, but is free for fully one-half its length.

In the brachial valve there are also two convergent plates bounding the deltidial cavity, larger and stronger than those of the opposite valve. These plates may rest upon the bottom of the valve, and, toward the posterior extremity, probably always do, but anteriorly they become free, forming a spondylium which is supported by a median septum extending beyond the anterior edge of the plate. Thus these two valves, which are very similar in exterior, the pedicle-valve being only slightly the more convex and with a low median sinus, are also closely alike on the interior, each being furnished with a spondylium.

Type, *Syntrophia lateralis*, Whitfield (sp.).

Distribution. Cambrian (?)—Lower Silurian.

Camarophoria, King. 1846.

(Plate 45, figs. 5, 6.)

Subtrigonal, concavo-convex rhynchonelliform shells, with median fold and sinus well developed, and surface more or less strongly plicated. Beak sharp, incurved; deltidial plates in an incipient condition, often wanting.

In the pedicle-valve the dental plates converge, forming a moderately large spondylium which, in the umbonal region, rests upon the bottom of the valve, but anteriorly is supported by a vertical median septum. The spondylium is short, while the supporting septum is carried beyond it, sometimes to nearly one-half the length of the shell. Near the teeth, which are small, there are two accessory supporting lamellæ abutting on one side against the outer surface of the converging dental plates, and on the other against the interior cardinal surface of the valve; thus inclosing small lateral umbonal cavities. Muscular scars of this valve always obscure.

In the brachial valve the cardinal plate is narrow, subtriangular, in the typical species bearing a very small cardinal process, which in other species is rarely present. The hinge-plate is traversed by two fine divergent ridges running outward from

the beak and continuous beyond the anterior edge of the plate into long, slender and upwardly curving crura. Beneath the crura arises a broad, shallow, trough-shaped plate, which, near the apex, is supported by a short median septum resting on the valve. This process is strongly curved toward the opposite valve and is continued for most of its length beyond the termination of the median septum. Usually it widens outwardly, and then narrows rather abruptly, or even acutely, to its extremity. The adductor muscular scars are well developed in this valve, forming a broadly oval or subcircular impression.

Vascular sinuses are sometimes retained on both valves.

Type, *Camarophoria Schlotheimi*, von Buch (sp.) (Permian).

Distribution. Devonian — Permian.

Subgenus *Camarophorella*, Hall. 1893.

(Plate 45, figs. 5, 6.)

Valves biconvex and subcircular; without median fold, sinus and plications, the surface being smooth and regularly arched. Internal characters normal for *CAMAROPHORIA*, except that the broad, spatuliform spondylium rests upon the valve for most of its length, the median septum penetrating it and projecting above it into the interior cavity of the shell.

(Type, *Camarophorella lenticularis*, White and Whitfield (sp.). Burlington limestone.)

Camarella, Billings. 1859.

(Plate 45, figs. 13-19.)

Valves full, convex, smooth about the umbonal region, but anteriorly developing a few low plications which are rather the more conspicuous on the median fold and sinus, and the fold, sinus and plications are clearly developed on the usually abrupt anterior slope.

The pedicle-valve is the more convex up to maturity, but thereafter the brachial valve becomes the deeper. The beak of the pedicle-valve is erect or slightly incurved and beneath it lies a triangular delthyrium which, so far as observed, shows, neither in *C. Volborthi* nor in *C. Panderi*, any evidence of deltidial plates. The cardinal slopes are abrupt and oblique, and no cardinal area is developed on either valve. On the interior are dental lamellæ

which converge, and uniting, are supported by a short median septum, forming thus a well-defined spondylium.

In the brachial valve the hinge-structure is similar to that of *CAMAROTECCHIA*, the crural plates converging and forming a short, very small median cavity, which is supported by a long septum. The crura are short and the lateral divisions of the hinge-plate small. No cardinal process exists.

Type, *Camarella Volborthi*, Billings.

Distribution. Cambrian (?) — Lower Silurian.

Parastrophia, Hall. 1893.

(Plate 45, figs. 20-27.)

Shells broad, transversely oval in outline; surface with low rounded plications which are stronger on fold and sinus, apparent on the lateral slopes only near the margins of the valves. Brachial valve much the more convex, its umbo projecting conspicuously beyond that of the pedicle-valve. Cardinal margin straight and moderately long; no evidence of cardinal area in either valve.

In the pedicle-valve the delthyrium is broadly triangular and is usually filled, partially or wholly, by the beak of, the opposite valve. On the interior the dental lamellæ make a strong spondylium which reaches almost to the bottom of the valve, being supported by a very low median septum extending nearly one half the length of the shell.

In the brachial valve there are two vertical crural plates not connected by a cardinal process. These are slightly convex on their inner surfaces and at their point of greatest convexity they unite with two longitudinal and gradually convergent lamellæ, which form a spondylium narrower than that of the opposite valve and supported by a very low median septum somewhat longer than that of the pedicle-valve.

Type, *Parastrophia hemiplicata*, Hall (sp.). (Trenton limestone.)

Distribution. Lower — Upper Silurian.

Anastrophia, Hall. 1867.

(Plate 45, figs. 28-35.)

Shells with strongly reversed convexity. External surface covered with numerous fine and sharp dichotomizing ribs, extending to the apices of beaks and frequently crossed by delicate con-

centric lines. Interior with a spondylium in each valve as in *PARASTROPHIA*; that of the pedicle-valve is the wider and is supported by a median septum near its anterior extremity. In the brachial valve the convergent plates generally rest upon the inner surface of the shell, though sometimes the spondylium is supported at its anterior extremity. The crural plates are extravagantly developed, forming two broad wing-shaped vertical expansions, concave on their outer surfaces; their upper edges are curved over the hinge-line, their anterior edges broadly notched, and below this point appears the base of attachment for the crura; the walls of the spondylium being connected with them at the most convex point of their inner surfaces. The dental sockets are always small, and old shells frequently show a false foramen in the beak, which is simply an extension of the spondylium that does not appear to be accidental. The muscular impressions of this valve are frequently defined as a fourfold scar about the anterior end of the spondylium; in the pedicle-valve these impressions are rarely discernible.

Type, *Anastrophia Verneuli*, Hall (Lower Helderberg).

Distribution. Upper Silurian — Lower Devonian.

Porambonites, Pander. 1830.

(Plate 45, figs. 36-38.)

Synonym; *Isorhynchus*, King, 1850.

Shells robust, transverse or elongate, sometimes distinctly triangular and globose. Valves unequally convex, the brachial valve being always the deeper. Pedicle-valve with a sinus to which there is not always a corresponding fold on the opposite valve. Hinge-line straight; hinge-teeth very strong, resting on a broad hinge-plate. In both valves is a small obtusely triangular area, which is higher in the pedicle than in the brachial valve. Both valves with a broad pedicle-passage, never closed by a deltidium. Sometimes the beak of the brachial valve is so strongly incurved that its perforation is not visible from outside. On the lateral slopes is a more or less strongly defined pseudolunule.

In the interior of the pedicle-valve are two long, robust dental lamellæ which rapidly converge and unite, sometimes before the bottom of the valve is reached, then forming a low median

septum. Their anterior portion is always free while their posterior portions are sometimes coalesced into a single piece. In the brachial valve there are two short crural plates not rising to more than one-third the height of the shell; these may remain independent or sometimes unite to form a single piece.

The muscles are attached between and on the convergent plates, and, in the brachial valve, also in front of them.

Surface-sculpture variously punctate. Shell-structure apparently fibrous.

Type, *Porambonites intermedia*, Pander.

Distribution. Silurian.

Noetlingia, Hall. 1893.

Shells exteriorly like PORAMBONITES, with long, straight hinge-line, well-developed cardinal areas and biforate beaks.

There is a spondylium in each valve, that of the pedicle-valve being, at the outset, the larger, and continuing further forward than the other. Both are supported by a stout median septal callosity, which, in the brachial valve, widens and becomes lost in the thickened shell-substance of the muscular region; that of the pedicle-valve becomes narrowed anteriorly, and eventually leaves the spondylium free,



FIG. 443.—A cardinal view of a specimen of *Noetlingia Tscheffkini*, DE VERNEUIL (sp.).



FIG. 444. FIG. 445. FIG. 446. FIG. 447.



FIG. 448.

FIG. 449.

FIG. 450.

FIGS. 446-452.—Transverse serial sections of a single specimen of *Noetlingia Tscheffkini*, showing the structure of the internal apophyses and septa. In all the sections the pedicle-valve (P) is above, the brachial valve (B) below.

or nearly so. There is a simple linear cardinal process in the spondylium of the brachial valve.

Type, *Noetlingia Tscheffkini*, De Verneuil (sp.).

Distribution. Lower Silurian.

Lycophoria, Lahusen. 1885.

(Plate 45, figs. 36-38.)

Valves rotund and without median fold or sinus, so that the anterior margin of contact is almost straight, or very gently sinuous. Beaks full and closely incurved, only the pedicle-valve appearing to have retained a foramen, though the cardinal area is present in both. The brachial valve bears a hinge-plate which is recurved into the pedicle-cavity of the opposite valve, and is produced into a long, curved cardinal process, bifurcate at its extremity. The crural plates are connected with the elevated margins of the four adductor impressions. In the opposite valve the teeth are supported by divergent plates which extend forward for about one-half the length of the shell and rest upon the bottom of the valve. Externally the shell is smooth in the umbonal regions, but anteriorly is covered with low, rounded plications crossed by fine concentric lines.

Type, *Lycophoria nucella*, Dalman (sp.).

Distribution. Lower Silurian.

Conchidium, Linné. 1753.

(Plate 46, figs. 1-14.)

Synonyms; *Gypidia*, Dalman, 1828; *Zdimir*, Barrande, 1881; *Antirhynchonella*, Quenstedt, 1871.

Shells elongate-subtrigonal or subpentagonal in outline, strongly inequivalve, biconvex; median fold and sinus faint, if at all developed. Anterior margins of contact usually straight, with sometimes a faint fold, at others a low sinus on both valves. Surface with numerous sharp or rounded, simple or divided plications extending from beaks to margins; cardinal slopes broad and usually smooth.

In the pedicle-valve the umbo is elevated, attenuated, more or less incurved, not prone upon the opposite valve. No cardinal area is developed. The delthyrium is very broad and bears a concave deltidium, which, however, is frequently wanting. Teeth small, supported by convergent lamellæ which unite in the interior cavity and form a single median vertical septum of variable length; in the typical species usually extending almost, and sometimes quite to the anterior margin, and vertically, for

fully one-half the depth of the combined valves. The spondylium is very narrow and deep; combined with the median septum the height of these plates equals fully two-thirds the depth of the valve. The anterior margins of these plates are doubly incurved, the most projecting points being at the base of the septum, and at its line of union with the dental lamellæ. The median septum consists of two vertical lamellæ, each continuous with one of the component plates of the spondylium. The spondylium was the seat of muscular attachment, and it bears a series of fine radiating lines along its median portion, and transverse or concentric lines over its lateral slopes; the former probably representing the scar of the adductor, and the

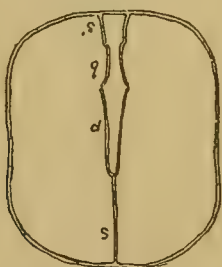


FIG. 451.

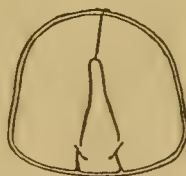


FIG. 452.

FIG. 453.—*Pentamerus (Conchidium) Knighti*. A transverse section in the umbonal region.

- | | |
|----------------------------------|--|
| s. Septum of the pedicle-valve. | p. Dental plates forming ventral spondylium. |
| s'. Septa of the brachial valve. | b. Crural plates resting on the septa. |

FIG. 454.—*Conchidium laqueatum*, Conrad. Transverse section, showing the deflection of the median septum, the deep, narrow spondylium of the pedicle-valve, and the septa of the brachial valve bearing inclined crural processes.

latter the impressions of the diductor muscles. In the brachial valve the beak is obtuse and closely incurved into the deltidial cavity or spondylium of the opposite valve. The dental sockets are long and narrow, their inner margins being bordered by two broad, convergent crural plates, which extend toward the bottom of the valve, but do not reach it. These sloping plates are supported by two vertical septa, with which they are united, not at their extremities, but obliquely, just within their free edges. At the anterior angles of these free edges, there are two long, straight or slightly curved, rod-like crural processes extending into the anterior cavity of the shell. Beneath the beak is a faintly developed, bilobate or multilobate cardinal process. The muscular scars lie on the surface of the valve between the two

vertical septa, and extend for some distance in front of them. They are divided by a low axial ridge.

Shell-substance fibrous, impunctate.

Type, *Conchidium biloculare*, Linné (= *Gypidia* or *Pentamerus conchidium*, Dalman *et al.* Upper Silurian limestone, Gotland.)

Distribution. Upper Silurian — Devonian.

Pentamerus, Sowerby. 1813.

(Plate 47, figs. 1-9.)

Smooth shells, of variable contour, sometimes bearing a few broad and obscure radiating undulations. There is no median fold and sinus, though a median prolongation of the valves, defined by two divergent lateral furrows, is a normal character. A concave deltidium is sometimes retained, and a faint lobation



FIG. 453.

FIG. 454.

FIG. 455.

FIG. 456.

Fig. 453. *Pentamerus oblongus*, Sowerby. A transverse section, showing the septa.

Figs. 454, 455. Transverse sections of the septa of *Pentamerus oblongus*. Fig. 454 shows the septum of the pedicle-valve and the inclosure of its base by the shell-substance of the valve. Fig. 455 is an enlargement of the septa of the brachial valve, and shows a thin coating of testaceous matter upon the inner faces of the prismatic walls.

Fig. 456. *Pentamerus cylindricus*, Hall. A transverse section, showing the septa.

of the apical end of the spondylium is the sole evidence of a cardinal process. The depth of the spondylium and septal cavity varies with the convexity of the valves. Sometimes the septa unite before reaching the inner surface of the brachial valve and the spondylium thus formed is supported by a low axial septum.

Type, *Pentamerus oblongus*, Sowerby.

Distribution. Upper Silurian — Lower Devonian.

Barrandella, Hall. 1893.

Synonym; *Clorinda*, Barrande, 1879.

(Plate 48, figs. 1-5.)

Galeatiform pentameroids with median fold on the brachial valve and median sinus on the pedicle-valve. Shells small, surface smooth or rarely plicate.

The pedicle-valve bears a short spondylium supported only at its posterior surface, the free extension being produced forward and upward into the cavity of the opposite valve; the crural plates of the brachial valve are concave on their outer surfaces and supported by convergent septa uniting as they reach the valve and leaving but a single median line of union on its surface.



FIG. 457.



FIG. 458.

FIG. 457. *Barrandella linguifera*, Sowerby. Transverse section near the anterior extremity of the median septum in the pedicle-valve; showing the form of the spondylium.

FIG. 458. *Barrandella barrandii*, Billings. A transverse section in front of the termination of the median septum of the pedicle-valve; showing the form of the spondylium in both valves, and the coalescence of the septa in the (lower) brachial valve.

Strong vascular, or ovarian sinuses radiate from the umbonal region of the pedicle-valve. These are complicated with the undefined diductor scars and are, therefore, to a certain extent, of muscular origin.

Type, *Barrandella linguifera*, Sowerby (sp.).

Distribution. Upper Silurian — Devonian (?).

Pentamerella, Hall. 1867.

(Plate 48, figs. 6-15.)

Shells with median fold and sinus as in *BARRANDELLA*, usually larger and strongly plicate, possessing a very narrow cardinal area, an elongate pseudo-area, and incipient deltidial plates. The median septum on the interior of the pedicle-valve is very short, and at times is altogether absent. In the brachial valve the crural plates and supporting septa form a distinct spondylium which is broadly sessile on the surface of the valve.

Type, *Pentamerella arata*, Conrad (sp.).

Distribution. Devonian.

Sieberella, Ehlert. 1887.

(Plate 48, figs. 16-21.)

Galeatiform pentameroids having the median fold on the pedicle-valve and the median sinus on the brachial valve. Surface plicate without evidence of cardinal area or deltidial plates.

Pedicle-valve with well-developed median septum, and moderately long spondylium which is free for fully two-thirds its length. In the brachial valve of typical examples from the Gotland and Wenlock limestones no spondylium is formed; the septa supporting the crural plates resting directly on the surface of the valves.



FIG. 459.



FIG. 460.

FIG. 461.—Transverse section of *Sieberella galeata*, near the beaks, the pedicle-valve being uppermost; showing the discrete septa of the brachial valve.

FIG. 462.—*Sieberella Sieberi*, von Buch. Transverse section, showing the form of the spondylla.

This is, however, a variable feature, the septa not infrequently forming a spondylium supported by a median septum.

Type, *Sieberella Sieberi*, von Buch (sp.).

Distribution. Upper Silurian — Lower Devonian.

Gypidula, Hall. 1867.

(Plate 48, figs. 22-28.)

Shells with the contour of *SIEBERELLA*, plicate or smooth. Pedicle-valve with a well-defined, true, cross-striated cardinal



FIG. 461.—*Gypidula comis*, Owen (sp.). A transverse section in front of the short median septum of the pedicle-valve; showing the form of the spondylla.

area, and narrow, but erect or convex, incipient deltidial plates. On the interior the teeth are unusually strong, the septum very short, the spondylium being free for most of its length. In the opposite valve the dental sockets are distinct, the crural plates expanded nearly horizontally, being divided at their beginning by a narrow median cardinal process. The inner moiety of the crural plates is deflected to a vertical or slightly divergent position and in this form they are produced anteriorly. These plates rest upon two broadly convergent septa which unite with the valve making a sessile spondylium, which is acute at its anterior extremity, and lies at, or in front of the center of the

valve. The character of this structure in the brachial valve is not variable in this genus.

Type, *Gypidula comis*, Owen (sp.).

Distribution. Devonian.

Capellinia, Hall. 1893.

(Plate 47, figs. 10-12.)

Shells large, elongate-subovate; the relative size and convexity of the valves, normal for *Pentamerus*, are here reversed, the brachial valve being the larger and deeper, with full, strongly arcuate and incurved umbo and beak, the apex of which is concealed within the delthyrium of the opposite valve. The pedicle-valve has an acute suberect beak which is not arched posteriorly, but rises directly from the cardinal margins. Below it is a broad delthyrium without evidence of deltidial plates; there is no hinge-line, but the margins of the delthyrium make sub-acute angles with the lateral margins of the valve. Cardinal slopes very broad and abrupt. The surface of the pedicle-valve is flattened above, while that of the brachial valve is evenly and deeply convex; it also shows a tendency to trilobation or obscure radical plication. The arrangement of the internal septa and spondylium is the same as in *Pentamerus oblongus*, except that the supporting-septa of the brachial valve are higher and more nearly vertical.

Type, *Capellinia mira*, Hall.

Distribution. Upper Silurian.

Stricklandinia, Billings. (1863), 1859.

(Plate 49, figs. 1-7.)

Shells usually large, elongate-oval, transversely-oval or circular; in some species with a straight hinge-line, more or less extended. Valves nearly equal, varying from depressed convex to strongly convex. In the interior of the pedicle-valve is a short median septum supporting a small, triangular chamber beneath the beak. In the brachial valve are two very short or rudimentary socket plates, which in some species bear prolonged crura. Both valves with distinct cardinal area, that of the pedicle-valve the larger, the dorsal area sometimes incurved over the ventral, and concealing it wholly or in part.

Muscular impressions not clearly defined in the pedicle-valve, but in the brachial valve are two oblong or subovate scars a little below the beak, one on each side of the median line

Type, *Stricklandinia Gaspensis*, Billings.

Distribution. Upper Silurian.

Amphigenia, Hall. 1867.

(Plate 49, figs. 8-15.)

Shells elongate-ovoid, high-shouldered, broadest behind and sloping to a narrow curve anteriorly; without median fold and sinus. Surface smooth, with irregularly distant concentric growth-rings and faint radial striæ. There is no cardinal area, and deltidial plates are not developed in the large triangular delthyrium. In the pedicle-valve is a short spondylium formed by the union of the dental lamellæ with the median septum. The muscles were implanted upon this spondylium and there is no evidence of scars elsewhere upon the valve except those left by the vascular sinuses upon the post-lateral surfaces. In the brachial valve is a large subquadrate hinge-plate, perforated by the visceral foramen which with age becomes filled up by adventitious deposits. The crura are long, straight, inclining upward or toward the opposite valve and are expanded at their extremities into palmate processes. The muscular scars in this valve are sharply developed, forming together an elongate adductor area, clearly divisible into an attenuate anterior pair and a broader posterior pair. The former have about twice the length of the latter and are marked by transverse, fine, closely-set wrinkles; the latter are radiately and coarsely striate. From the posterior termination of this area to beneath the hinge-plate extends a broad, smooth sinus, from which is given off a pair of strong lateral branches, which ramify over the genital area in the umbonal region.

The substance of the shell is impunctate on the surface. Beneath the epidermal layer is another that is highly punctated; within this, and apparently forming the innermost lamina, is a third layer whose surface is minutely wrinkled.

Type, *Amphigenia elongata*, Vanuxem (sp.).

Distribution. Lower Devonian (Corniferous limestone).

Rensselæria, Hall. 1859.

(Plate 46, figs. 1-15.)

Shells ovate or elongate-ovate in outline, subovoid in contour, broadest posteriorly; valves unequally convex, with a more or less distinct median elevation on both. Cardinal slopes broadly flattened in the typical species. Lateral margins compressed, often strongly inflected.

Pedicle-valve with full, scarcely salient umbo; beak acute, incurved, with terminal foramen. Beneath and on each side of the beak is a concave, sharply defined space, but no proper cardinal area. Distinct deltidial plates divided by a median suture may be present, but they are usually concealed by incurvature or atrophied by the encroachment of the umbo of the opposite valve. On the interior the teeth are prominent but not thickened, widely divergent and close within the margins of the valve. They are supported by stout dental plates which rest for most of their length upon the bottom of the valve, but are free along their posterior margins. These plates are closely appressed against the lateral walls of the shell and become coalescent therein in later growth-stages. The muscular impression is restricted to the posterior portion of the valve, covering a very narrow longitudinal area. Between the dental plates at the bottom of the pedicle-cavity lies a narrow median scar, and in front of this, a very deep, elongate impression, which is sometimes clearly divided into central adductor scars embraced by the diductor impressions. Over the post-lateral slopes are numerous fine, irregularly ramifying sinuses.

The brachial valve is considerably the less convex and is often flattened. The beak is minute and usually obscured by the overlapping pedicle-valve. The hinge plate is large, flat, triangular, sometimes thin, often thickened on its posterior portion and resting on the bottom of the valve. It is separated from the lateral shell-walls by narrow dental grooves, widening at their extremities. Normally this plate is perforated by a visceral foramen entering at the under side and opening at or beneath the apex of the beak, but usually this perforation is closed by adventitious deposits. The crura are continuations of the upper portions of the supporting septa; they are broadened just beyond their base of attachment, and from their upper angles are given off the

jugal processes, which are long, pointing upward and inward but not uniting. From the lower angles the descending arms take their origin, following the curves of the valve, diverging for a short distance, thence abruptly approaching, and uniting to form a broad, elongate, acutely triangular plate, which is not supported by a median septum, or otherwise connected with the valve. From the center of the posterior margin of the plate arises a small rod-like process, which extends for a short distance upward toward the crura.

The muscular area is less clearly delimited than that of the opposite valve, and its component scars are not often distinctly defined. It is, however, broader and longer than on the pedicle-valve, and is divided transversely into anterior and posterior adductor scars, the former being the larger, and their surface covered by branching lines radiating from a median longitudinal ridge. From the narrow and somewhat elevated posterior extremities of this area extends a broad median sinus, on either side of which arises a stout vascular trunk bending backward and over the post-lateral slopes. Secondary branches are given off from both its margins. These vascular markings of the genital region are rarely well defined.

Surface of the shell distinctly plicated, with sparse concentric wrinkles near the anterior margin. The radial lines may be fine or coarse, but no species is known in which the surface is entirely smooth.

Shell-substance punctated beneath the epidermal layer.

Type, *Rensselaeria ovoides*, Eaton (sp.). Oriskany sandstone.

Distribution. Lower Devonian.

Subgenus *Beachia*, Hall. 1893.

(Plate 51, figs. 1-7.)

Shells lentiform in general contour; moderately and sub-equally convex; both valves with an obscure and undefined median fold. The beak of the pedicle-valve is prominent, never incurved sufficiently to conceal its deltidial plates and foramen. The cardinal margin beneath the beak is flattened into a well defined pseudo-area, and the short inflection of the margin beginning here is continued along the lateral portion of the

shell, where it meets a similar marginal inflexion from the opposite valve. These produce the sharp introversion of the lateral margins which is also one of the characteristics of the genus *MEGALANTERIS*.

The surface of the valves is covered with fine, hair-like radiating striae, which are often visible only near the margins or at their thickened extremities on the inflexed portions of the shell.

On the interior the dental lamellæ are short and do not rest upon the valve. The hinge-plate is supported by two vertical septa, the median cleft and visceral foramen are more or less obscured and with sometimes a bilobed callus in its place. The brachidium has long, straight jugal processes and the triangular anterior plate in numerous specimens shows that the posterior rod-like process from the median ridge of that plate extends upward almost to the crura, but terminates abruptly and has no connection whatever with the latter.

(Type, *Beachia Suessana*, Hall. Oriskany sandstone).

Newberria, Hall. 1891.

(Plate 51, figs. 12-19.)

Shell elongate-ovoid, having the general contour and external aspect of *RENSSELERIA* and *AMPHIGENIA*, but without the strongly radiate-striate surface prevailing in the former genus and less strongly developed in the latter. The greatest convexity of the valves is in the umbonal region, or above the middle of their length, and in some forms the surface is distinctly flattened over the lateral slopes, leaving the median portion of the valves very prominent and sometimes subangular. The cardinal and lateral margins are regular, even and not inflected.

The pedicle-valve has the rostrum produced and incurved, the apex slightly truncated by the subcircular foramen; deltidial plates small and obscure. The teeth are comparatively small, projecting forward and gently upward, free at their extremities and supported by narrow dental plates which join the bottom of the valve above the middle of its length and are continued forward as slender, widely divergent ridges upon the inner surface, gradually merging into the shell.

In the bottom of the rostral and umbonal cavity is a broad, usually ill-defined muscular area, from which radiates a series of vascular ridges and depressions extending into the marginal region of the valve. The diductor scars are situated posteriorly and deeply impressed; between and in front of them is a narrow, elongate adductor scar which is rarely divided medially and often extends forward to, or beyond the center of the valve. On each side of the muscular impression is a thickened area, very narrow at its origin in the rostral region or pedicle-cavity and produced into divergent ridges, usually two on each side, and a fifth in the median axis. These may extend to the margins or disappear before reaching the middle of the valve and are variously subdivided by vascular grooves and sinuses emanating from them.

In the brachial valve the hinge-plate is small, similar to that of *RENSSELÆRIA* and *AMPHIGENIA* in general form, but is of relatively less size than in the former genus and is not perforated by a visceral foramen opening beneath the apex. Two very narrow, almost linear and closely submarginal dental sockets extend nearly to the apex; within them lie two broad, sub-triangular crural plates, which are divided by a triangular median fissure extending to the bottom of the valve. The inner anterior angles of these plates bear the slender crural processes, the extent of which is unknown. In mature individuals the apical portion of the hinge-plate is peculiarly constructed; the latter areas become more or less completely united, without altogether obliterating the median triangular fissure, and above this point the surface is excavated into a spoon-shaped cavity, when the development is extreme, or is transversely angular in the average individual. At a short distance from the hinge-plate and in the bottom of the valve there arises a low median ridge, which continues for a short distance, separating the obovate, narrowly flabelliform scars of the anterior and posterior adductor muscles. The anterior scars are considerably the larger, and their surface is longitudinally striated. The vascular grooves and ridges are more obscurely developed than in the pedicle-valve.

Shell-substance finely punctate.

Surface smooth or covered with fine concentric striae, accompanied by stronger wrinkles of growth. The inner laminae are sometimes marked by obscure radiating striae near the margins of the valves.

Type, *Newberria Johannis*, Hall.

Distribution. Middle Devonian.

Centronella, Billings. 1859.

(Plate 52, figs. 1-7.)

Shells plano-convex or concavo-convex. Pedicle-valve with acute incurved beak, perforated at its extremity, the foramen being continuous with a partially closed delthyrium; medially ridged, and with abruptly sloping sides. On the interior the teeth are large, thick at their extremities and adherent to the lateral walls of the shell. Between them is a deep pedicle-cavity, in the bottom of which lie the elongate scars of the adductor muscles, and about their anterior portion the small, flabellate diductors.

The brachial valve is very shallow, rendered concave exteriorly by a median sinus which does not make itself apparent on the interior. Beak small, apex not incurved. Dental sockets broad, bounded interiorly by the high walls of the hinge-plate. This plate is divided medially by a deep furrow extending to the apex, and, therefore, consists of two processes which are elevated, thickened and rest on the bottom of the valve. From the anterior face of these arise the crura which converge for a short distance, and expand to form two broad, acute jugal processes. From here the lateral branches of the brachidium curve outward, gradually turning from a vertical to a horizontal position, broaden rapidly and unite to form an anterior triangular plate which bears a median ridge, where the two lateral branches are conjoined. The whole of the anterior portion of the brachidium is inclined gently upward toward the cavity of the opposite valve.



FIG 462.—*Centronella glans-fagea*, Hall. A preparation showing the brachidium. (ROMINGER.)

The muscular impressions occupy an elongate area below the hinge-plate, and are divided by a median ridge, but are only obscurely divisible into their elementary scars. The lateral portions of this valve frequently bear a series of vascular sinuses in the pallial region.

Surface smooth or with concentric lines crowded near the margins of the valves. Shell-substance punctate.

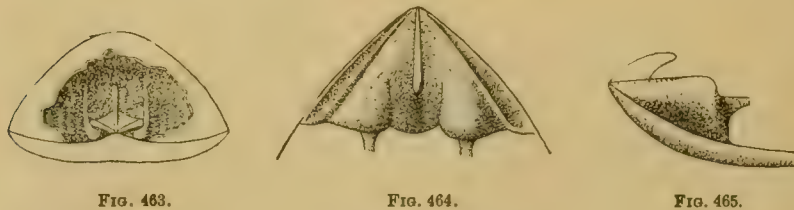
Type, *Centronella glans-fagea*, Hall. Upper Helderberg group.

Distribution. Devonian.

Subgenus *Oriskania*, Hall. 1893.

(Plate 52, figs. 11-13.)

Shells large with the characteristic naviculoid form and smooth exterior of *CENTRONELLA*. The form of the brachidium has not been determined, but there is every reason to infer that it differs in no essential features from that of *CENTRONELLA*. The hinge-



Oriskania navicella, Hall.

FIG. 463. A cardinal view; showing the hinge-plate and the elevation of the narrow median crest or cardinal process. The specimen also retains the teeth of the pedicle-valve and a portion of the dental lamellæ, though the latter are broken near the surface of the valve.

FIG. 464. An enlargement of the hinge-plate; showing the crural lobes and the extent of the cardinal process.

FIG. 465. A profile of the same specimen; showing the thickness of the plate and the uncinatiform form of the cardinal process. $\times 3$.

plate is elongate-triangular, continuous between the crural bases, and bears a median vertical crest, or cardinal process, which begins at the apex, rises rapidly in height, and extends for fully one-half the length of the plate on its upper edge, but at its base

is shortened and constricted, forming a projecting cardinal spur.

(Type, *Oriskania navicella*, Hall. Oriskany sandstone.)

Subgenus *Selenella*, Hall. 1893.

Shells with biconvex valves, smooth exterior, terebratuliform outline, narrow at the umbones and broad in the pallial region. The brachidium is similar to that of *RENSSELERIA* and *CENTRONELLA*; the anterior plate broader and less attenuate than in



FIG. 466.



FIG. 467.



FIG. 468.

Selenella gracilis, Hall.

FIG. 466. Outline profile of conjoined valves.

FIG. 467. Preparation showing the form of the loop.

FIG. 468. An oblique view; showing the upward curvature of the anterior plate. $\times 3$.

RENSSELERIA and without the central, rod-like posterior extension, and also lacks the median ridge or thickening along the symphysis of the lateral elements, which exists in *CENTRONELLA*.

(Type, *Selenella gracilis*, Hall. Upper Helderberg group.)

Subgenus *Romingerina*, Hall. 1893.

(Plate 52, figs. 14, 15.)

Shells, small biconvex; smooth valved. The median ridge on the anterior plate of the brachidium is elevated into a conspicuous vertical lamella, extended both anteriorly and posteriorly, being in fact a double plate produced by the abrupt deflection of each lateral branch of the brachidium near the median line; union taking place along the upper edge, which almost reaches the inner surface of the pedicle-valve.

The upper edge, where viewed from the side, is flatly roof-shaped, while the lower edge describes two convexities, the greater anterior, leaving a notch between them. The surfaces

of the loop and median plate are covered with minute, obliquely conical pustules, in some cases seeming to become spinulose.



FIG. 469.



FIG. 470.

Romingerina Julia, A. Winchell.

FIG. 469. A restoration of the loop; showing the extent of the median plate.

FIG. 470. A profile view; showing the elevation of this plate, the double curvature of its upper margin and its fimbriated edge. $\times 4$.

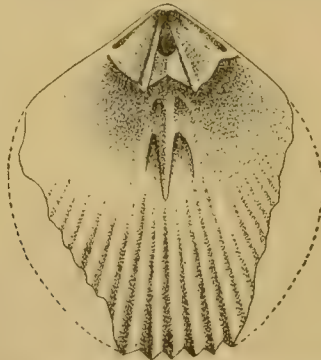
(A. WINCHELL.)

(Type, *Romingerina Julia*, A. Winchell (sp.). Upper Devonian — Lower Carboniferous.)

Trigeria, Bayle. 1875.

(Plate 52, figs. 8-10.)

Plicated centronellids with plano-convex valves. In the brachial valve the hinge-plate is tripartite, the median division

FIG. 471. *Trigeria Guerangeri*, de Verneuil (sp.).

The interior of the brachial valve; showing the perforated hinge-plate and the muscular scars. (EHLERT.)

being perforated by a visceral foramen. Brachidium as in CENTRONELLA, though with a smaller anterior plate.

Type, *Trigeria Guerangeri*, de Verneuil (sp.).

Distribution. Devonian.

Scaphiocœlia, Whitfield. 1891.

Shells of great size; plano-, or concavo-convex in contour. Pedicle-valve with a conspicuous dorsum and broad, flat lateral slopes; brachial valve with an angular median sulcus. Surface strongly plicated. Interior unknown. Shell substance fibrous impunctate (?).

Type, *Scaphiocœlia Boliviensis*, Whitfield.

Distribution. Devonian.

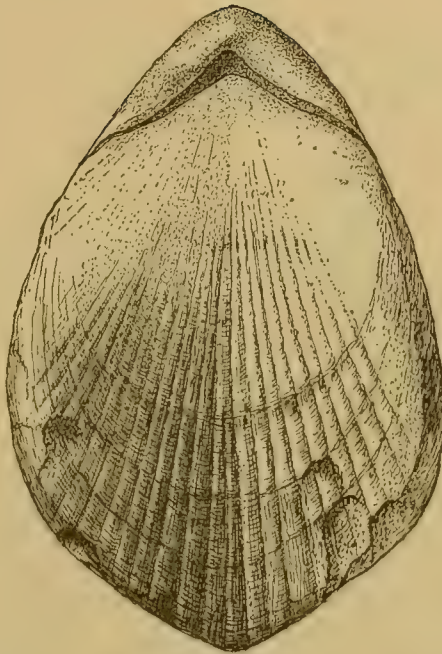


FIG. 472.

Scaphiocœlia Boliviensis, Whitfield.

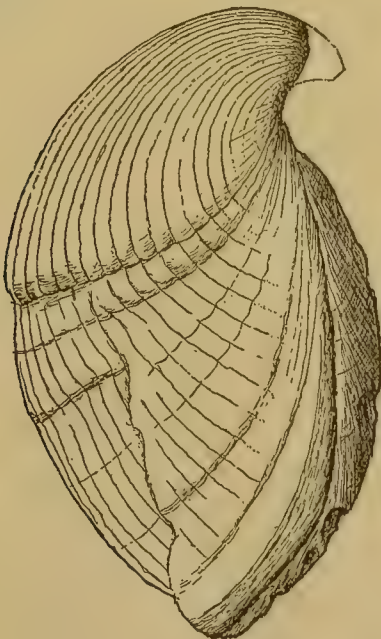


FIG. 473.

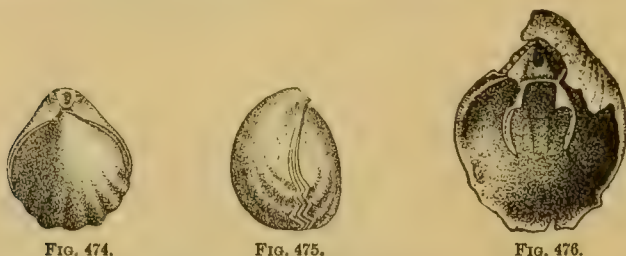
FIGS. 472, 473. Two views of the same individual, showing the external characters of the species. (WHITFIELD.)

[?] Notothyris, Waagen. 1882.

Shells biconvex, coarsely plicate. Hinge-plate tripartite, perforated as in *CENTRONELLA*. Of the brachidium only the descending lamellæ are known.

Type, *Notothyris subvesicularis*, Davidson (sp.).

Distribution. Devonian? — Carboniferous.



Notothyris subvesicularis, Davidson.

FIG. 474. A dorsal view of the exterior.

FIG. 475. A profile of the same shell.

FIG. 476. The interior of the brachial valve; showing the perforated hinge-plate and the lateral lamellæ of the loop. (WAAGEN.)

Juvavella, Bittner. 1890.

Shells smooth, biconvex, with a low median sinus on the pedicle-valve. Brachial valve with a very short loop, the descending branches uniting to form an expanded vertical median plate.



FIGS. 477, 478. *Juvavella Suessi*, Bittner. (BITTNER.)

Type, *Juvavella Suessi*, Bittner.

Distribution. Trias.

Nucleatula, Bittner. 1890.

Shells having the general external aspect of those of *JUVAVELLA* but with a larger loop in which the vertical median plate is highly developed and fimbriated on its anterior margins.



FIGS. 479-484. *Nucleatula retrocita*, Suess (sp.) (BITTNER.)

Type, *Nucleatula retrocita*, Suess (sp.).

Distribution. Trias.

Dinarella, Bittner. 1892.

Small trigonal, smooth shells with deep margin at the sinus on the brachial valve. Foramen suboval, deltidial plates partially developed. Brachial valve with a median septum; brachidium



FIGS. 485-490. *Dinarella Haueri*, Bittner. (BITTNER.)

composed of descending lamellæ, which converge and unite to form a free vertical median plate.

Type, *Dinarella Haueri*, Bittner.

Distribution. Trias.

Megalanteris, Suess. 1855.

(Plate 51, figs. 8-11.)

Shells large, smooth, equally biconvex; suboval in outline. Shell substance punctate. Cardinal and lateral margins of the

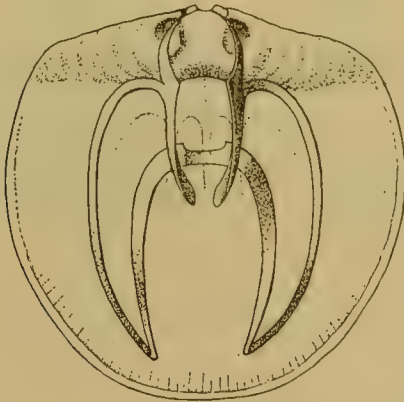


FIG. 491.



FIG. 492.

Megalanteris Archiaci, de Verneuil.

FIGS. 491, 492. A restoration of the brachial apparatus.

(Suess.)

valves inflected. Apex of the pedicle-valve truncated by a foramen, beneath which lies a triangular delthyrium from which

the deltidial plates have almost invariably been displaced. The muscular scars of this valve are deep and sharply defined, but restricted to the posterior portion of the shell. In the brachial valve, the hinge-plate is elevated into a stout, erect, subcylindrical cardinal process, whose posterior face is grooved and striated. Brachidium extending for nearly the entire length of the valves; jugal processes depressed, long and convergent; descending lamellæ arising at an angle from the crura; ascending lamellæ deeply reflected. Impressions of the adductor muscles long, narrow and obscure.

Type, *Megalanteris Archiaci*, de Verneuil.

Distribution. Devonian.

Enantiosphen, Whidborne. 1893.

Shells large, with smooth biconvex valves having broadly introverted margins; general external aspect as in *MEGALANTERIS*. Interior with a strong ventral median septum.

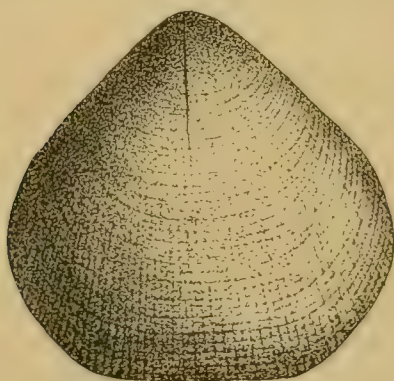


FIG. 493.



FIG. 494.

FIGS. 493, 494. *Enantiosphen Vicaryi*, Davidson (sp.)

(DAVIDSON.)

Type, *Enantiosphen Vicaryi*, Davidson (sp.)

Middle Devonian (Torquay).

Cryptonella, Hall. 1861.

(Plate 52, figs. 16-23.)

Valves subequally convex; elongate-oval in outline, broadest in the pallial region. Pedicle-valve with prominent, erect or slightly incurved umbo; deltidial plates well developed; foramen circular, apical, rarely encroaching upon the umbo, or becoming

oval as in many species of *DIELASMA*; the inverted pedicle-sheath or collar is slightly developed within the aperture. The teeth are strong and supported by dental lamellæ which divide the umbonal cavity into three chambers; near the apex they join the somewhat thickened scar of the pedicle-muscle, and extend beyond its anterior margin with a slight convergence, always resting on the bottom of the valve. The pedicle-muscle makes the strongest scar of all the muscular bands, the adductors being narrow and central, and the diductors scarcely delimited.

In the brachial valve the hinge-plate is large, elongate and concave; it is divided by two low ridges diverging from the apex, and from these the plate rises toward the sides into decidedly elevated socket-walls; between the diverging ridges the surface is rather deeply depressed, and, toward the apex, is perforated by a circular foramen. The crura are slender, very short, curving inward and upward, making two long and narrow crural apophyses. The descending lamellæ are carried forward, following the curves of the valves for nearly two-thirds the length of the shell, and abruptly reflected; the ascending lamellæ returning to within a short distance of the crural apophyses. The whole structure is very similar to the brachidium of the adult living *MAGELLANIA* (*WALDHEIMIA*).



FIG. 495. *Cryptonella planirostra*, Hall. The brachidium; showing the long descending and ascending lamellæ.

The adductor scars are more or less distinct, the anterior members being the more clearly defined. These scars are usually represented only by three straight lines diverging from the umbonal region. Vascular sinuses originate about the muscular areas of both valves and are directed forward with frequent ramifications.

The shell-structure is highly punctate.

Type. *Cryptonella rectirostra*, Hall.

Distribution. Devonian—Lower Carboniferous.

Subgenus *Eunella*, Hall. 1893.

(Plate 52, figs. 24-28.)

Shells exteriorly like *CRYPTONELLA*.

The brachidium, compared with that of *CRYPTONELLA*, is quite short, extending less than one-half the length of the brachial

valve, and the recurvature of the ascending branches exceedingly slight. This recurved lamella is so delicate that it is rarely completely preserved, but when retained, the entire brachidium has



FIG. 496.



FIG. 497.

FIG. 496. *Eunella simulator*, Hall; showing the character of the hinge-plate, the relative length and usual preservation of the brachidium, with the ascending band lost.

FIG. 497. *Eunella Sullivanti*, Hall; a dorsal view of the complete brachidium.

the form represented in the adjoining figure. The crural apophyses are situated more anteriorly than in *CRYPTONELLA* and are much broader at the base.

Type, *Eunella Sullivanti*, Hall (sp.). Devonian.

Harttina, Hall. 1893.

(Plate 52, figs. 29-31.)

Shells plano-convex or naviculoid; brachial valve depressed-convex or nearly flat and the pedicle-valve medially ridged with abrupt slopes at the sides. Dental lamellæ of the pedicle-valve well developed. In the brachial valve there is a short, tripartite hinge-plate, supported by a median septum of considerable height in the umbonal region and extending for fully one-half the length of the valve, becoming low anteriorly.

The crura are very short and are continued almost immediately into the long convergent crural apophyses. The descending branches of the brachidium extend for nearly the entire length of the shell, following the curvature of the valve and approaching each other anteriorly, their extremities being again directed outward. The ascending branches extend backward to points not far in front of the crural apophyses, where they are united by a transverse band. The outer margins of the descending

lamellæ are fringed with rather long, irregularly set spinules directed toward the commissure of the valves. There are no spinules elsewhere on the brachidium.

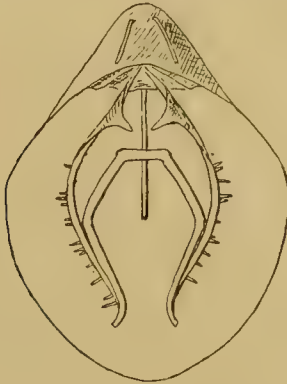


FIG. 498.

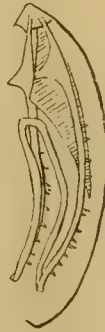


FIG. 499.

Centronella (Harttina) Anna, Hartt.

Dorsal and profile views of a preparation of the brachidium; showing the hinge-plate, broad jugal processes, fimbriated descending lamellæ, long recurved lamellæ, and a prominent median septum in the brachial valve.

Type, *Harttina Anna*, Hartt (sp.).

Distribution. Carboniferous.

Dielasma, King. 1859.

(Plate 52, figs. 10-25.)

Synonym; *Epithyris*, King (not Phillips), 1850.

Shells biconvex; outline usually elongate-oval; frequently a median sinus, with or without a plication at the bottom of it, is developed in both valves.

The apex of the pedicle-valve is closely incurved, so that in adult shells but little remains of the deltidial plates. The foramen is large, quite generally encroaching upon the umbo and often becoming very oblique to the longitudinal axis; with the increase of this obliquity the deltidial plates are thickened on their inner surface, which thus becomes more or less protruded. The inverted sheath or collar within the foramen is highly developed and clearly shown on internal casts. On the interior the dental plates are conspicuous, and stand vertically upon the bottom of the valve, not showing the convergence and often actual union occurring in *CRYPTONELLA*.

In the brachial valve the dental sockets are quite deep and narrow, the socket-walls rising abruptly, though not attaining the height of the dental plates of the opposite valve. They are distinctly separated from the crural plates or margins of the hinge-plate, and converge toward the apex, where they merge into a slightly elevated cardinal process; the latter usually appearing



FIG. 500. *Dielasma bovidens*, Morton. An enlargement of the umbonal portion of the brachial valve, showing the slightly thickened processes on either side of the beak.

as a crescentic submarginal wall, though when best preserved is seen to be composed of two lateral, somewhat rounded lobes. The crural plates are two divergent vertical lamellæ, originating just below the cardinal process, and attaining a length equal to the distance between their extremities, which is about one-third the width of the valve at that point. Between these plates lies the long, shallow hinge-plate, which is raised but little above the bottom of the valve, and is sometimes actually adherent to it. This plate attains its greatest width at the extremities of the vertical crural plates, its margins converging thence anteriorly, its full length often equaling one-third that of the valve. To this plate are attached all the muscles of the brachial valve, the scars of both anterior and posterior adductors being frequently clearly defined upon its surface. The lateral divisions of the plate have become merged with the valve and lost. The median division, which is also to a certain extent myiferous in *CRYPTONELLA*, is carried to an extreme of development in *DIELASMA*, where it forms a distinct platform. The crura are greatly abbreviated. The descending lamellæ of the brachidium are attached



FIG. 501. *Dielasma elongatum*, Schlotheim. The interior of the umbonal region of the two valves, showing the highly developed dental plates (*d*), the elongate, sessile hinge-plate with its muscular scars, and the form and mode of attachment of the brachidium. (DAVIDSON.)

to, and are continuous with the crural plates, as far as the latter extend. The crural apophyses on the upper margins of these lamellæ are developed behind the points where the lower margins of the lamellæ are free from the crural plates. The lateral parts of the brachidium are more or less divergent, the recurvature of the ascending lamellæ rather short and the

entire structure does not extend beyond the middle of the shell. The ascending lamellæ are very fragile and usually destroyed in fossilization.

Type, *Dielasma elongatum*, Schlotheim (sp.).

Distribution. Devonian (?) — Permian.

Subgenus *Cranæna*, Hall. 1893.

(Plate 53, figs. 4-9.)

Biconvex shells having the hinge-plate constructed as in *CRYPTONELLA* and not adherent to the bottom of the valve as in *DIELASMA*; the crura also arise normally from the lateral divisions of this plate. Form of the brachidium as in *DIELASMA*, its descending branches being highly divergent, the ascending branches abruptly recurved, making a broad, gentle curvature above; at the same time this recurved band is so very fragile as to be almost invariably destroyed. The entire length of the loop, as in *DIELASMA*, and in contradistinction to *CRYPTONELLA* and *EUNELLA*, is about one-third that of the brachial valve.



FIG. 502. *Cranæna Romingeri*, Hall, (sp.). An outline showing the *DIELASMA*-form of the brachidium and the divided hinge-plate.

(Type, *Cranæna Romingeri*, Hall (sp.). Devonian.)

Dielasmina, Waagen. 1882.

Plicated shells which possess more or less of the characters of *DIELASMA*. They have the dental plates of the pedicle-valve and



FIG. 503.

Dielasmina plicata, Waagen.

Dorsal and front views.

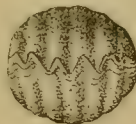


FIG. 504.

(WAAGEN.)

the general form of the brachidium in that genus, as far as the interior is now known.

Type, *Dielasmina plicata*, Waagen.

Distribution. Carboniferous.

Hemiptychina, Waagen. 1882.

Plicated biconvex shells without dental plates, but with the hinge-structure and brachidium of *DIELASMA*.



FIG. 505. *Hemiptychina Himalayensis*, Davidson.

A portion of the interior; showing the absence of dental plates in the pedicle-valve, and the *DIELASMA*-like brachidium. (WAAGEN)

Type, *Hemiptychina Himalayensis*, Davidson (sp.).

Distribution. Carboniferous — Permian.

Beecheria, Hall. 1893.

(Plate 53, figs. 1-3.)

Non-plicated shells in which the dental plates are absent or represented only by faint ridges which do not reach the bottom of the pedicle-valve.

The peculiar myiferous hinge-plate of *DIELASMA* is wholly merged with the valve, but the crural ridges are still retained and the descending lamellæ originate from them at the bottom of the



FIG. 506. *Beecheria sublaevis*, Waagen (sp.)

Dorsal view: showing the smooth exterior. (WAAGEN.)



FIG. 507. *Beecheria Davidsons*, Hall.

An enlarged profile of the brachidium; showing the manner in which lamellæ arise from the bottom of the valve, the broad posterior jugal processes and the much narrower descending lamellæ. The anterior transverse or reflected band is not fully retained.

valve in very much the same way as in *DIELASMA*. The crural apophyses are broad and erect, there being no part of the descending branches behind them. Sometimes the brachial valve retains a low muscular impression which has the form of the platform of *DIELASMA*.

Type, *Beecheria Davidsons*, Hall.

Distribution. Carboniferous.

(?) *Cryptacanthia*, White and St. John. 1867.

Shells small plano-convex or naviculoid. Loop long and recurved; jugal processes united above. (?) Outer margins of the brachidium covered with spines.

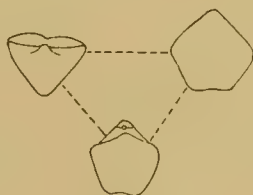


FIG. 508.

Cryptacanthia compacta, White and St. John.

A copy of the original figure.

(WHITE and ST. JOHN.)

Type, *Cryptacanthia compacta*, White and St. John.

Distribution. Carboniferous.

Stringocephalus, DeFrance. 1827.

(*emend.* Sandberger. 1842.)

Shells varying in outline from transverse to elongate-oval; biconvex, the brachial valve being somewhat the deeper; the greater convexity is in the umbonal region, giving to the brachial valve a high-shouldered appearance.

On the pedicle-valve the beak is somewhat narrow, its apex being abruptly attenuate, acute and often greatly incurved. From beneath the beak diverge two sharp ridges extending to the extremities of the hinge, and delimiting the broad cardinal excavations which seem to constitute a true cardinal area. The delthyrium is broad and triangular; in young shells it may be wholly open or incompletely closed by the imperfectly developed deltidial plates, while at maturity it is closed, with the exception of a circular foramen, and in old shells the deltidial plates are anchylosed, forming a single plate which becomes incurved, and the foraminal passage is thus obscured, and may take the form of a tube or sheath prolonged into the umbonal cavity.

On the interior the teeth are short, free and curved upward at their extremities. In the middle of the valve is a vertical longitudinal septum, which extends from the beak to near the anterior margin. This septum is short and thick posteriorly, but becomes

thinner and higher towards the front, ending abruptly in the pallial region.

In the brachial valve the umbo is obtuse. The cardinal area is distinctly developed and divided by a very broad triangular fissure, the covering of which (chilidium) is frequently retained, much modified by the presence of the great cardinal process. The dental sockets are comparatively shallow. The general form of the hinge-plate is triangular, with its apex anterior; its central portion is separated from the narrow, blade-shaped lateral divisions and is produced into a great cardinal process, rounded

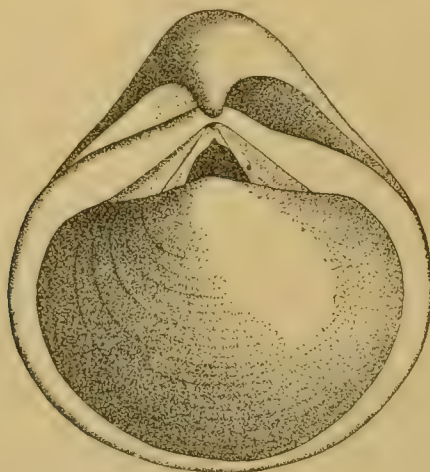


FIG. 509. *Stringocephalus Burtini*, DeFrance.

Dorsal views of two individuals; showing the differences assumed in growth by the umbo of the pedicle-valve. (QUNSTEDT.)

posteriorly, narrow and sharp on its anterior surface, and produced upward and backward into the cavity of the opposite valve. At the edge of the median septum of that valve it bifurcates, sending out a short clavate apophysis on either side of it. The lateral portions of the hinge-plate begin at the socket-walls which are high and narrow, extend downward, inward and forward to the anterior extremity of the plate, whence they curve upward into the crura. The crura are long, broadened and curved upward towards their extremities where the primary arms of the brachidium arise at a sharp angle. The latter curve backward and outward, and skirt the inner margins of the valves

as a very broad, continuous lamella, which is not reflexed though somewhat curved upward on the anterior margin. From the inner margins of this lamella, on its exterior and lateral



FIG. 510.



FIG. 511.

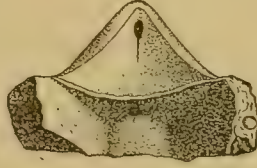


FIG. 512.

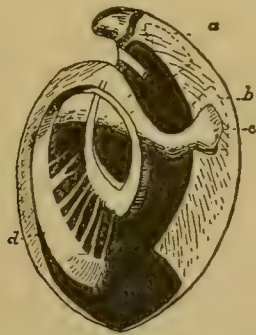
Stringocephalus Burtini, DeFrance.

FIG. 510. Umbonal cavity of the pedicle-valve with discrete deltidial plates.

FIG. 511. The internal sheath or projection of the pedicle-passage.

FIG. 512. The umbonal cavity of a pedicle-valve in which coalescence of the deltidial plates is almost complete. (QUENSTEDT.)

extension, arises a series of linear processes converging toward, and some of them perhaps reaching the crura. A low, thick median septum extends for about half the length of the valve.

FIG. 513. *Stringocephalus Burtini*, DeFrance.

A restoration of the interior, showing the internal pedicle-sheath and the strong median septum of the pedicle-valve; the great cardinal process, one of its terminal lobes (c) lying on either side of the septum; the form of the loop with the radial filaments extending from the anterior lamellae (d) to the crura. At (a) is the insertion of the diductor muscle, (b) that of the adductor. (HOERNES.)

The muscular impressions on both valves are exceedingly obscure, and have never been fully described or illustrated.

Surface smooth, with fine concentric growth-lines; sometimes a low median sinus exists on both valves near the margin.

Shell-substance impunctate externally, but the inner laminae are sparsely perforated.

Type, *Stringocephalus Burtini*, Defrance. Middle Devonian.

Tropidoleptus, Hall. 1857.

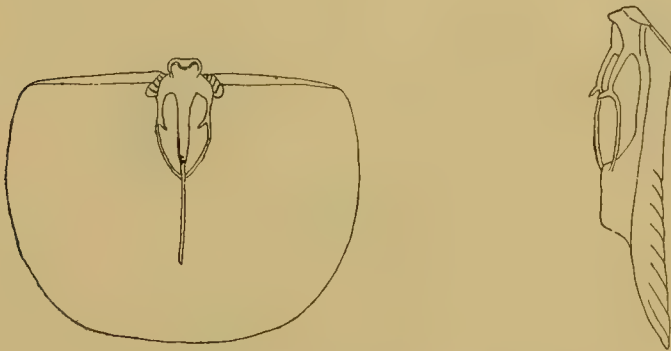
(Plate 54, figs. 1-11.)

Shells with the general external aspect of *RAFINESQUINA*; concavo-, or plano-convex. Hinge-line straight; in young shells forming the greatest transverse diameter and frequently extended at the cardinal extremities, but in mature and old shells shorter than the transverse diameter in the pallial region. Marginal outline varying from longitudinally semi-elliptical in youth, to transversely subelliptical at maturity. Surface covered with simple, low plications, all extending from beak to margins. The median plication on the pedicle-valve and the corresponding sinus on the brachial valve are broader and more conspicuous than the others.

The pedicle-valve is regularly convex, becoming slightly concave on the cardinal slopes. It bears a moderately broad cardinal area, coextensive with the hinge-line, which is divided by a broad, open delthyrium, which, in no observed condition of growth, bears a covering of any sort, but is filled by the cardinal process of the other valve. The base of the delthyrial cavity is thickened and transversely striated, probably by the attachment of the pedicle-muscle. The teeth are not situated at the extremities of the delthyrial margins, but lie within and in front of them, arise from the bottom of the valve as two erect, divergent subquadrate crests, resting upon low ridges which bound the muscular area. These peculiar teeth are smooth and abrupt on their inner faces, while their outer faces are deeply crenulated. A low groove separates each from the cardinal area. The muscular area is broadly flabellate, extending more than half-way across the valve, and consists of two large diductor scars enclosing a narrow median pair of adductors.

The brachial valve is slightly concave, often nearly flat. Cardinal area narrow, but clearly developed; chilidium prominent. Cardinal process large, erect, smooth on its posterior surface, and

bilobed at its summit. Each of these lobes is excavated above so that the upper portion of the posterior wall is free from the rest of the process. In front of this is a broad, smooth floor, sloping toward the bottom of the valve. The margins of this area form the elevated socket-walls, and their anterior extremities are the bases of the crura. The dental sockets are deep and their outer walls corrugated for the reception of the teeth. The posterior portion of the sockets and the lower part of the cardinal process are covered by the erect, convex chilidium. At the anterior edge of the cardinal process lies a broad, thick, not elevated median ridge, which gradually narrows and becomes developed



Tropidoleptus carinatus, Conrad.

FIG. 514. The interior of the brachial valve; showing the cardinal process, crenulated dental sockets, loop and median septum.

FIG. 515. The same in profile; showing the height of the median septum and the mode of attachment of the lamellæ of the loop.

into a sharp, thin septum, attaining its highest point at about the center of the valve, whence it slopes rather more abruptly downward, terminating at the anterior third of the valve. From the crural bases extends a pair of long, slender lamellar processes, which curve outward, are directed upward, again converge and unite with the median septum on its lateral faces and just in front of its highest point. Slightly convergent, slender jugal processes are given off not far from the origin of the lateral lamellæ. The scars of the adductor muscles are situated just in front of the cardinal process on either side of the septum, and are not clearly delimited.

Shell-substance highly punctated in all its parts.

Type, *Tropidoleptus carinatus*, Conrad (sp.).

Distribution; Lower and middle Devonian.

NOTE.—In the treatment of the post-palæozoic genera of the terebratuloids it has seemed necessary and appropriate to defer to the opinions of other authors, and therefore desirable, at least for the purposes of the American student, to consider them separately from the palæozoic genera, following in a general way the accepted interpretation of their affinities, but not often expressing a judgment as to the generic value of their characters.

[?] *Cruratula*, Bittner. 1890.

MAGELLANIA-like shells, with median septum in the brachial valve, punctate shell, but with the lateral or descending branches of the loop not united, so far as known.



FIGS. 516, 517. *Cruratula Eudora*, Laube (sp.). (BITTNER.)

Type, *Cruratula Eudora*, Laube (sp.).

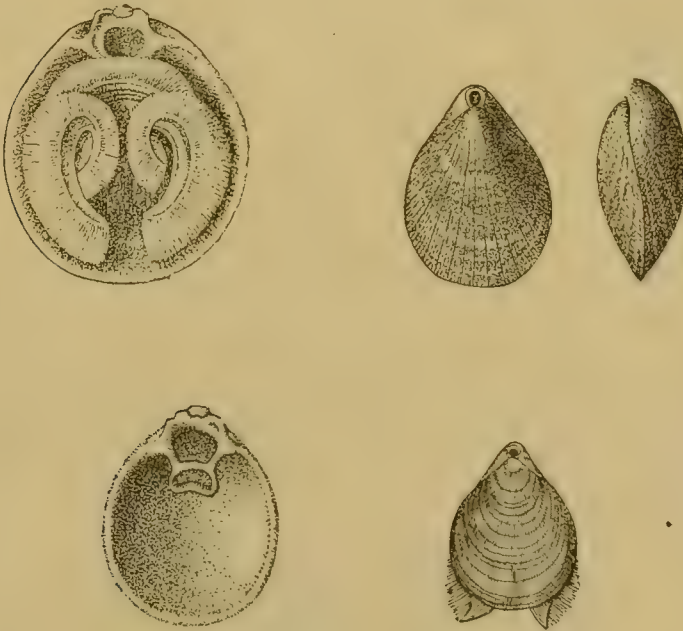
Distribution. Trias.

Terebratulina, d'Orbigny. 1847.

Shells biconvex; ovate in outline. Cardinal extremities faintly auriculate. Beak of pedicle-valve truncated by a circular foramen; deltidial plates small. Surface finally radiate. Interior

of pedicle-valve without dental plates. In the brachial valve the cardinal process is slightly developed; hinge-plate and median septum wanting; socket walls prominent, supporting a short loop which is rendered annular by the union of the oval processes.

Brachia as in *LIOTHYRINA*, the median unpaired arm being small. Each lobe of the mantle bears four sinuses; genital



FIGS. 518-522. *Terebratulina caput-serpentis*, Linné (sp.). (DAVIDSON; BARRETT.)

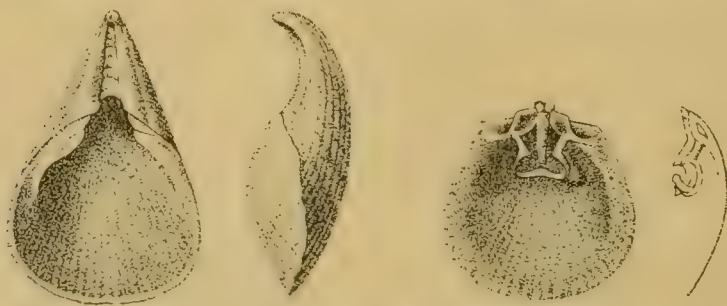
glands six, two in each mantle lobe and two in the visceral cavity.

Type, *Terebratulina caput-serpentis*, Linné (sp.).

Distribution. Jurassic — Recent (Arctic, Boreal, Lusitanian, West African, Indo-Pacific, Australo-Zealandian, Japanese, Aleutian, Californian, Magellanian, Caribbean and Transatlantic Provinces).

Subgenus *Agulhasia*, King. 1871.

Shells small, with highly elevated arcuate umbo, elongate-triangular false cardinal area divided by a median depression, the foramen lying at its base. Loop as in *TEREBRATULINA*.

FIGS. 523-526. *Agulhasia Davidsoni*, King. (DAVIDSON.)

Type, *Agulhasia Davidsoni*, King.

Distribution. Cretaceous (?)—Recent (South African Province).

[?] *Disculina*, Deslongchamps. 1884.

Shells plano-convex; surface sharply plicated. Cardinal area distinctly developed: foramen large, encroaching upon the apex of the brachial valve. Cardinal process bilobed; accompanied by a divided chilidium (?). Loop not known.

FIGS 527, 528. *Disculina hemisphaerica*, Sowerby (sp.). (DAVIDSON.)

Type, *Disculina hemisphaerica*, Sowerby (sp.).

Distribution. Jurassic.

Terebratula, Klein. 1753

Synonym; *Lampas*, Meuschen, 1787.

Shells elongate, biconvex, smooth. Apex of pedicle-valve broadly truncated; foramen circular. Brachial valve with two

broad plications most conspicuous at the margins. Loop probably short, with slightly recurved ascending lamellæ; jugal processes not united above.

(It has been shown by DOUVILLÉ that the term *TERBRATULA*, though introduced by LLHWYD in 1699, can only derive a definite significance from the determinations by KLEIN in 1753. KLEIN's first species is *T. simplex*, which is the same as the *Concha anomia* of COLONNA (1676) and the last author's figure which is reproduced by KLEIN, and also inserted here, represents one of the extensive group of the *Terebratulæ biplicatæ*. From LINNÉ's description of his *Anomia terebratula* (1758), which is also based upon this shell, it is inferred that the species thereby represented is a fossil from the Mesozoic or Tertiary formations, though its geological horizon is not more precisely known.)



FIG. 529 *Terebratula simplex*. (COLONNA, KLEIN, EHLERT.)

Liothyrina, Ehlert. 1887.

Synonym; *Liothyris*, Douvillé, 1880.

Shells biconvex, unPLICATED. Loop short, transverse lamella bent upward in the middle; oral process discrete; cardinal



FIGS. 530, 531. *Liothyrina vitrea*, Born (sp.). (DAVIDSON.)

process small, hinge-plate divided. Muscular scars restricted to the posterior portion of both valves.

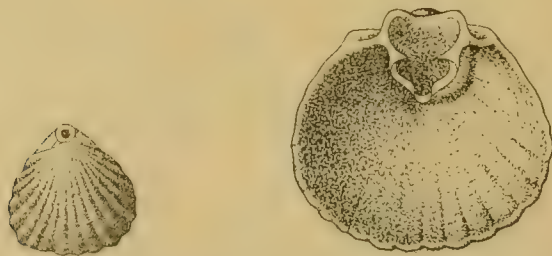
Animal with long, free brachia united at the base by a membranous expansion.

Type, *Liothyryna vitrea*, Born (sp.).

Distribution. Tertiary — Recent (Arctic, Lusitanian, West African, Indo-Pacific, Australo-Zealandian, Japanese, Californian, Panamic, Peruvian, Magellanian, Patagonian and Caribbean Provinces).

Eucalathis, Fischer and Ehlert. 1890.

Shell small, auriculate; valves convex, covered with radiating plications. In the interior are neither dental plates nor septa. Cardinal process distinct. Loop short; descending branches with oral processes distinct, and directly in front of them the lamellæ are deflected into a transverse band which



FIGS. 532, 533. *Eucalathis Murrayi*, Davidson (sp.). (DAVIDSON.)

bears a narrow median fold. Brachia but slightly developed, scarcely longer than the loop and arranged in two lobes.

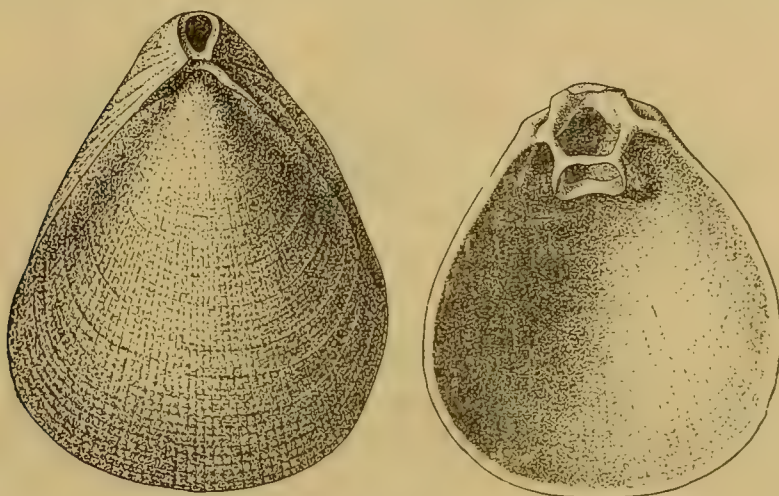
Type, *Eucalathis Murrayi*, Davidson (sp.).

Distribution. Recent (Lusitanian Province).

Dyscolia, Fischer and Ehlert. 1890.

Shells of large size, subtrigonal, faintly auriculate; valves convex with radiating surface striæ. Beak short, foramen large, deltarium concave, transversely striated, much thickened in old shells. On the interior neither septum nor dental plates. In the brachial valve there is no hinge plate. Loop broad and short, descending processes united anteriorly by a transverse band as in *LIOTHYRINA*. Brachia represented by a subrectangular brachial

disk, slightly bilobed in front and extending beyond the loop for one-third of its length. This disk is bordered by cirri.



FIGS. 534, 535. *Dyscolia Wyvillii*, Davidson (sp.). (DAVIDSON.)

Type, *Dyscolia Wyvillii*, Davidson (sp.).

Distribution. Recent (West African and Caribbean provinces).

Subgenus *Glossothyris*, Douvillé. 1880.

Shells like *LIOTHYRINA* but with a deep median sinus on the brachial valve. Loop short, anterior transverse band slightly recurved.



FIGS. 536-538. *Glossothyris nucleata*, Schlotheim (sp.). (QUENSTEDT.)

(Type, *Glossothyris nucleata*, Schlotheim (sp.). Jurassic.)

Pygope, Link. 1830.

Synonyms; *Antinomia*, Catullo, 1850; *Pugites*, de Haan, 1833.

Shells normally biconvex when young, but with increasing age the median growth of the valves is arrested, and by the continued

growth of the lateral portions the shell becomes bilobed, the two lobes inclosing a perforation situated posteriorly in the median line. Loop short.



FIG. 539. *Pygope diphya*, Colonna (sp.). (WOODWARD).

Type, *Pygope diphya*, Colonna (sp.).

Distribution. Jurassic.

Propygope, Bittner. 1890.

Shells small with the naviculoid contour of *AULACOTHARIS* but with a short loop. Dental plates absent. Brachial valve with a short median septum.



FIGS. 540-543. *Propygope Hagar*, Bittner. (BITTNER.)

Type, *Propygope Hagar*, Bittner.

Distribution. Trias.

Subgenus Zugmayeria, Waagen. 1882.

Shells biplicate; loop short; with strong dental plates and without crural plates.



FIGS. 544-547. *Zugmayeria rhætica*, Zugmayer (sp.). (ZUGMAYER)

Type, *Zugmayeria rhætica*, Zugmayer (sp.).

Distribution. Triassic.

Subgenus *Rhaetina*, Waagen. 1882.

Shells biplicate; loop short, supported by crural plates; dental plates absent.

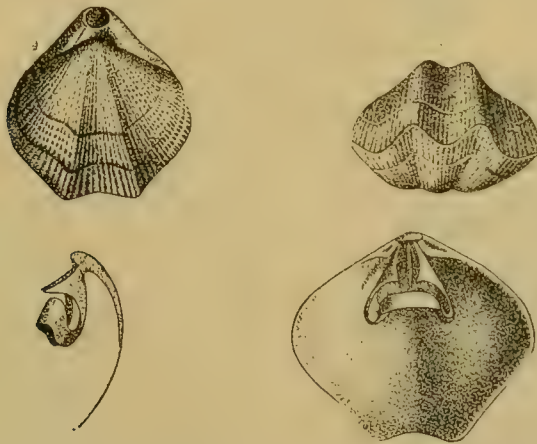


FIGS. 548-551. *Rhaetina gregaria*, Suess (sp.). (ZUGMAYER.)

(Type, *Rhaetina gregaria*, Suess (sp.). Triassic.)

Subgenus *Dictyothyris*, Douvillé. 1880.

Shells subnaviculate, with median fold and sinus on brachial and pedicle-valves respectively. Surface covered with short spinules. Dental plates are present in the pedicle-valve. In the



FIGS. 552-555. *Dictyothyris coarctata*, Parkinson (sp.). (DAVIDSON)

brachial valve is a well-developed cardinal process and faint median septum; the loop is short, its anterior band being broad and considerably reflected.

(Type, *Dictyothyris coarctata*, Parkinson (sp.). Jurassic.)

Magellania, Bayle. 1880.

Synonym; *Waldheimia*, King. 1850; *Neothyris*, Douvillé. 1880.

Shells biconvex, ovate or subpentagonal. Surface plicate or smooth. Beak of the pedicle-valve broadly truncated. Deltidial

plates well developed. Pedicle-valve without dental plates. In the brachial valve is a conspicuous trilobed cardinal process and a hinge-plate supported by a median septum which may be more or less developed. Loop long, extending nearly to the anterior

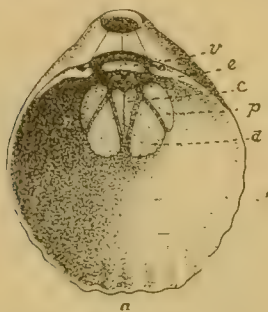


FIG. 556.

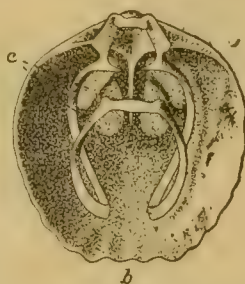


FIG. 557.

FIGS 557, 558. *Magellania flavescens*. a, pedicle-valve; b, brachial valve; c, adductor scars; d, diductors; e, accessory diductors; p, ventral pedicle-muscle; v, median pedicle-muscle. (DAVIDSON.)

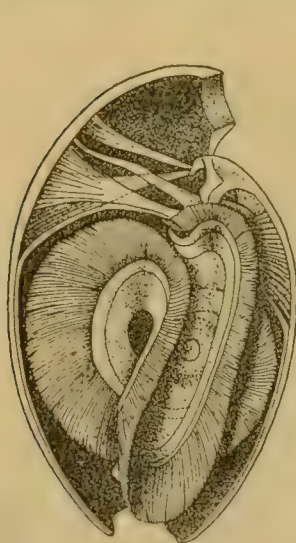


FIG. 558.

FIG. 559. *Magellania flavescens*, showing the brachia. (DAVIDSON.)

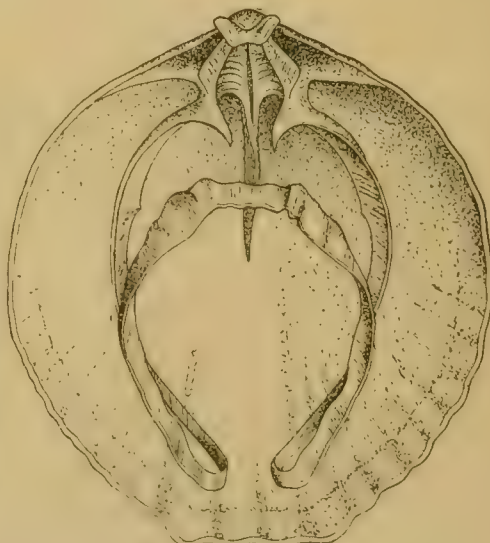


FIG. 560.

FIG. 560. The brachial supports of *Magellania flavescens*. (HANCOCK.)

margins of the valves; oral processes large, not united; ascending branches extending backward to or beyond the center of the shell and united by a stout transverse lamella. Muscular area posterior in both valves.

Mantle with four trunk sinuses on each lobe; of the genital glands two pairs lie in the dorsal lobe and four in the ventral lobe. Structure and arrangement of the brachia as in *TEREBRATULINA*.

Type, *Magellania flavescens*, Lamarck (sp.).

Distribution. Jurassic — Recent (Arctic, Australo-Zealandian, Japanese, Peruvian and Magellanian Provinces).

Dallina, Beecher. 1893.

Magellaniiform shells, with long, recurved loop, small cardinal process and well developed dorsal median septum. The adult condition of the loop is attained by a series of metamorphoses in



FIG. 560.



FIG. 561.

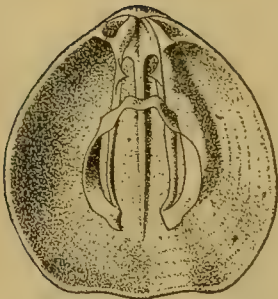


FIG. 562.



FIG. 563.

FIGS. 560-563. *Dallina septigera*, Lovén (sp.).

immature conditions resembling successively the mature brachidium in *PLATIDIA*, *ISMENIA* and *MÜHLFELDTIA*.

Type, *Dallina septigera*, Lovén (sp.).

Distribution. Tertiary — Recent (Arctic, Boreal, Lusitanian, Japanese and Transatlantic Provinces).

Cænothyris, Douvillé. 1880.

Shells elongate-oval, smooth. Dental plates highly developed, becoming calloused with age. Hinge-plate large, tripartite and supported by a median septum extending one-half the length of the shell. Cardinal process absent or very faint. Loop broad



FIG. 564, *Cænothyris vulgaris*, Schlotheim (sp.). (KOSCHINSKY.)

and moderately long, the ascending branches forming at their union a shield-shaped plate which is not attached to the median septum.

Type, *Cænothyris vulgaris*, Schlotheim (sp.).

Distribution. Trias.

Hynniphoria, Suess. 1858.

Small, subglobular smooth shells said to contain a "plowshare"-shaped process on the brachial apparatus. Imperfectly known.

Type, *Hynniphoria globularis*, Suess. Jurassic.

Macandrevia, King. 1859.

Shells biconvex, smooth, elongate-oval. Foramen large and without deltidial plates. Pedicle-valve with dental plates.

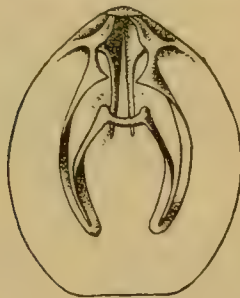


FIG. 565.



FIG. 566.



FIG. 567.

FIGS. 565-567. *Macandrevia cranium*, Müller (sp.). (DAVIDSON.)

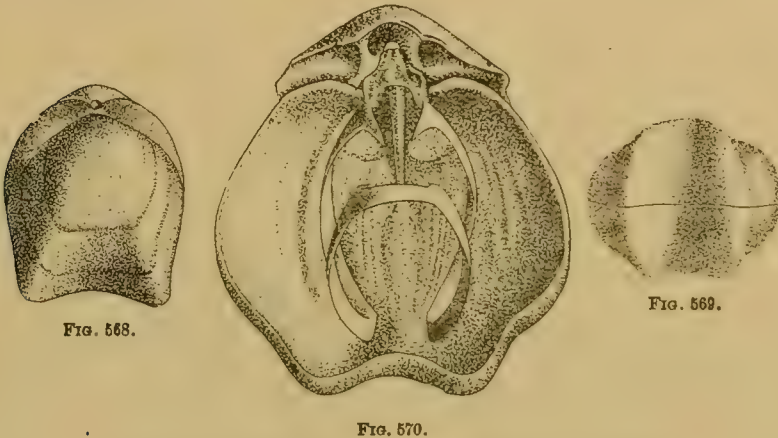
Brachial valve without cardinal process, but with crural plates and sometimes the remnant of a median septum. Loop in its mature condition similar to that of *MAGELLANIA*.

Type, *Macandrevia cranium*, Müller (sp.).

Distribution. Recent (Boreal, Lusitanian and Japanese Provinces.)

Subgenus *Zeilleria*, Bayle. 1878.

Shell with biplicate brachial valve, dental plates and long loop.



FIGS. 568-570. *Zeilleria cornuta*, Sowerby (sp.). (DAVIDSON.)

(Type, *Zeilleria cornuta*, Sowerby (sp.). Jurassic.)

Subgenus *Fimbriothyris*, Deslongchamps. 1884.

Shells biconvex, elongate, smooth in early growth, developing marginal angular plications at maturity.



FIGS. 571, 572. *Fimbriothyris Guerangeri*, Deslongchamps (sp.). (QUENSTEDT.)

(Type, *Fimbriothyris Guerangeri*, Deslongchamps, Jurassic.)

Subgenus *Antiptychina*, Zittel. 1883.

Shells elongate, brachial valve with broad median sinus, having elevated margins and a stout plication at its base. Dental plates and median dorsal septum well developed. Loop long and fimbriate.



FIGS. 573-575. *Antiptychina inversa*, Quenstedt (sp.). (QUENSTEDT.)

(Type, *Antiptychina bivallata*, Deslongchamps (sp.). Jurassic—Cretaceous.)

Subgenus *Microthyris*, Deslongchamps. 1884.

Synonym; *Ornithella*, Deslongchamps, 1884.

Elongate-oval shells with smooth surface, abrupt anterior slopes, dental plates and long loop.



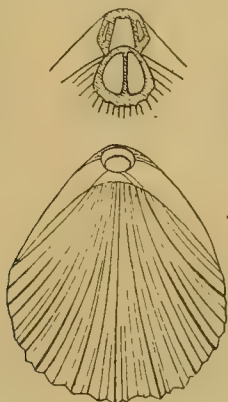
FIGS. 576-578. *Microthyris lagenalis*, Schlotheim (sp.). (DAVIDSON.)

(Type, *Microthyris lagenalis*, Schlotheim (sp.). Jurassic.)

Subgenus *Eudesia*, King. 1850.

Synonym ; *Flabellothyris*, Deslongchamps, 1884.

Biconvex shells, with dental plates, median dorsal septum, long recurved loop and sharply plicated exterior.



FIGS. 579, 580. *Eudesia cardium*, Lamarck (sp.). (DOUVILLÉ.)

(Type, *Eudesia cardium*, Lamarck (sp.). Jurassic.)

Subgenus *Orthotoma*, Quenstedt. 1871.

Shells small, subcircular, biconvex, smooth, with marginal median sinus on the brachial valve. Hinge-line straight.



FIGS. 581, 582. *Orthotoma Heyseana*, Dunker (sp.). (QUENSTEDT.)

(Type, *Orthotoma Heyseana*, Dunker (sp.). Jurassic.)

Subgenus *Aulacothyris*, Douvillé. 1880.

Shells smooth, naviculoid in contour; brachial valve with a broad median sinus, pedicle-valve with conspicuous median ridge. Dental plates and dorsal median septum well developed. Loop long, fimbriate.

(Type, *Aulacothyris resupinata*, Sowerby (sp.). Trias—Cretaceous.)



FIGS. 583-586. *Aulacothyris resupinata*, Sowerby (sp.). (DAVIDSON.)

Subgenus *Epicyrta*, Deslongchamps. 1884.

Smooth naviculoid shells with broad median sinus on pedicle-valve and corresponding elevation on the brachial valve.



FIGS. 587, 588. *Epicyrta Eugeniei*, von Buch (sp.). (QUENSTEDT.)

(Type, *Epicyrta Eugeniei*, von Buch (sp.). Jurassic.)

Subgenus *Plesiothyris*, Douvillé. 1880.

Shells biconvex, brachial valve biplicate. Dental plates and dorsal median septum present. Loop long.

(Type, *Plesiothyris Verneuilii*, Deslongchamps (sp.). Jurassic.)

Subgenus *Camerothyris*, Bittner. 1890.

Shells with the contour and loop of *AULACOTHYRIS*, but having the dental plates convergent and united.

(Type, *Camerothyris Ramsaueri*, Suess (sp.). Trias.)

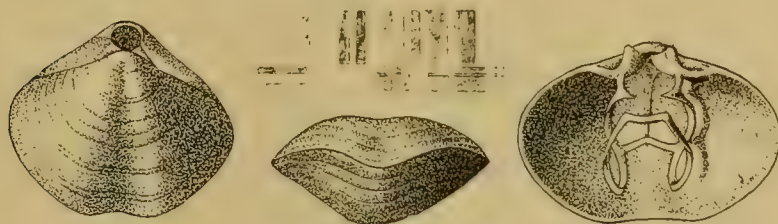


FIGS. 589-591. *Camerothyris Ramsaueri*, Suess (sp.) (BITTNER.)

(It is suggested by ÆHLERT that the genus *ORTHOIDEA*, Friren, 1875, is based on young shells of *Magellania numismalis*, Lamarck. Lias.)

Terebratalia, Beecher. 1893.

Magellaniiform shells, having the adult loop of precisely similar structure to that of *TEREBRATELLA*, but derived through a dissimilar series of metamorphoses, namely, through stages corresponding successively with the adult condition in *PLATIDIA*, *ISMENIA* and *MÜHLFELDTIA*.



FIGS. 592-594. *Terebratalia transversa*, Sowerby (sp.). (DAVIDSON)

Type, *Terebratalia transversa*, Sowerby (sp.).

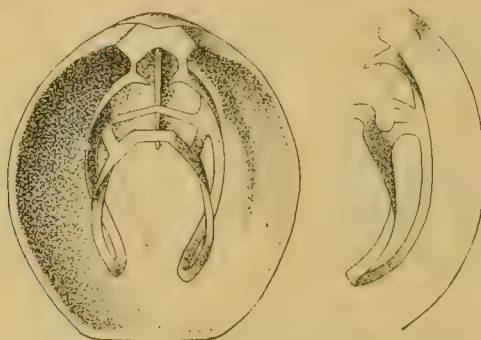
Distribution. Recent (Arctic, Boreal, Japanese, Aleutian and Californian Provinces).

Laqueus, Dall. 1870.

Synonym; *Frenula*, Dall, 1871.

Shells differing from *TEREBRATELLA* only in the structure of the loop, which bears two lateral processes, connecting the ascending

branches near the transverse band with the descending branches just in front of the oral processes.



FIGS. 595, 596. *Laqueus Californicus*, Koch (sp.). (DAVIDSON.)

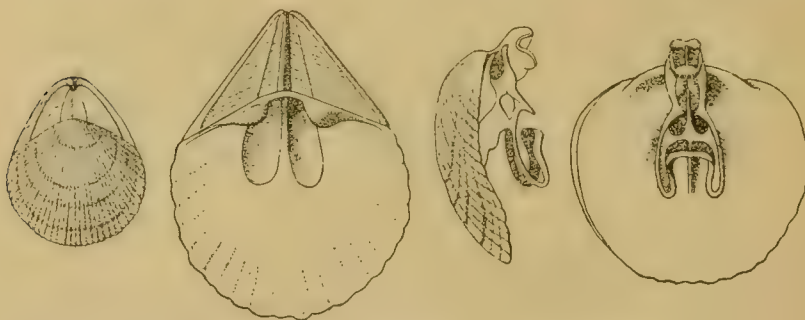
Type, *Laqueus Californicus* Koch (sp.).

Distribution. Recent (Boreal, Japanese and Californian Provinces).

Trigonosemus, Koenig. 1825.

Synonyms; *Fissurirostra*, d'Orbigny, 1847; *Fissirostra*, d'Orbigny, 1848; *Delthyridea*, King, 1850.

Shells planoconvex; surface radially plicate. Pedicle-valve with arched and prominent beak, sharply defined cardinal area,



FIGS. 597-600. *Trigonosemus elegans*, Koenig. (DAVIDSON.)

and minute apical foramen bounded beneath by coalesced deltidial plates. Cardinal process highly developed, bilobed. Loop as in *TEREBRATELLA*, but more narrow and elongate.

Type, *Trigonosemus elegans*, Koenig.

istribution. Cretaceous.

Terébratella, d'Orbigny. 1847.

Synonym; *Waltonia*, Davidson, 1850.

Shells biconvex, oval; surface plicate, rarely smooth. Cardinal area more or less distinctly defined on the pedicle-valve; foramen large, deltidial plates usually not united at maturity. Dental plates and sometimes a faint median septum are present. Brachial valve



FIGS. 601, 602. *Terebratella dorsata*, Gmelin (sp.); showing the mature and an immature condition of the loop. (DAVIDSON.)

with prominent cardinal process and divided hinge-plate. Loop long and recurved, the descending processes joined with the median septum by a pair of lateral lamellæ passing obliquely backwards.

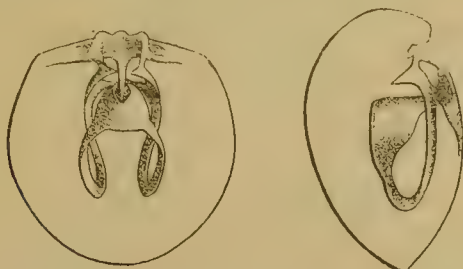
Type, *Terebratella dorsata*,* Gmelin (sp.).

Distribution. Jurassic — Recent (Australo Zealandian, Californian, Peruvian and Magellanian Provinces).

Kingena, Davidson. 1852.

Synonym; *Kingia*, Schloenbach, 1867.

Shell subglobose, smooth or tuberculated. Foramen circular, deltidial plates rudimentary. Pedicle-valve with dental plates;



FIGS. 603, 604. *Kingena lima*, DeFrance (sp.). (WOODWARD.)

brachial valve with broad cardinal process and a median septum. Loop long, recurved, as in *TEREBRATELLA*, but with the dorsal band

* On pp. 15, 17 and 76 this species is erroneously referred to as *Terebratalia dorsata*.

situated posteriorly, and the transverse band of the ascending branches developed into a broad saddle, the posterior margin of which incloses the median septum.

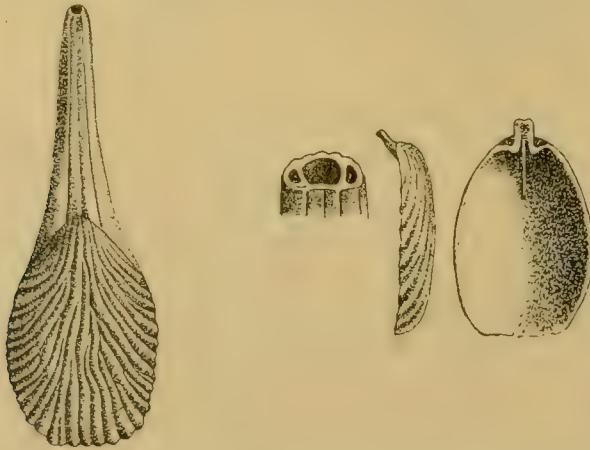
Type, *Kingena lima*, DeFrance (sp.).

Distribution. Cretaceous.

Lyra, Cumberland. 1816.

Synonym; *Terebrirostra*, d'Orbigny, 1847.

Plicated shells with the umbo of the pedicle-valve extravagantly elongated, terminating in an apical foramen. Deltidial plates very large; dental plates highly developed. Loop as in TERE-



FIGS. 605-608. *Lyra Meadi*, Cumberland. (DAVIDSON.)

BRATELLA in immature stages, the connecting lamellæ disappearing at maturity.

Type, *Lyra Meadi*, Cumberland.

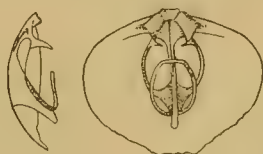
Distribution. Cretaceous.

Magasella, Dall. 1870.

Shells exteriorly as in TEREBRATELLA. Brachial valve with a highly developed median septum whose anterior extremity is elevated and free. Descending branches of the loop attached to this septum by broad expansions of the lamellæ; ascending branches forming a distinct ring, attached at its base to the

median septum a short distance above the insertion of the descending branches.

Type, *Magasella Adamsi*, Davidson (sp.).



FIGS. 609, 610. *Magasella Adamsi*, Davidson (sp.). (WOODWARD.)

Distribution. Recent (Australo-Zealandian, Japanese, Aleutian and Magellanian Provinces.)

Mühlfeldtia, Bayle. 1880.

Synonym; *Megerlia*, King, 1850.

Shells transverse or elongate, the transverse forms having a straight hinge-line and a well-developed cardinal area on each valve. Beaks low, foramen large, deltidial plates incomplete. Surface radiate. Cardinal process large. In the loop the descending processes unite anteriorly with the ascending branches, the latter being joined at their base to the median



FIGS. 611-613. *Mühlfeldtia truncata*, Linné (sp.). (DAVIDSON.)

septum, whence they bend forward and recurve. The lateral or basal portions of the ring thus formed are expanded and, in final stages of development, broadly perforated. Internal surface of the valves covered with radiating rows of pustules.

Type, *Mühlfeldtia truncata*, Linné (sp.).

Distribution. Tertiary — Recent (Lusitanian, West African, Indo-Pacific, Australo-Zealandian and Japanese Provinces.)

Ismenia, King. 1850.

Shells coarsely plicate with low umbones, large foramen and no cardinal area. Loop with descending and ascending branches coalesced with the median septum. The descending branches



FIGS. 614-616. *Ismenia pectunculoides*, Schlotheim (sp.). (QUENSTEDT.)

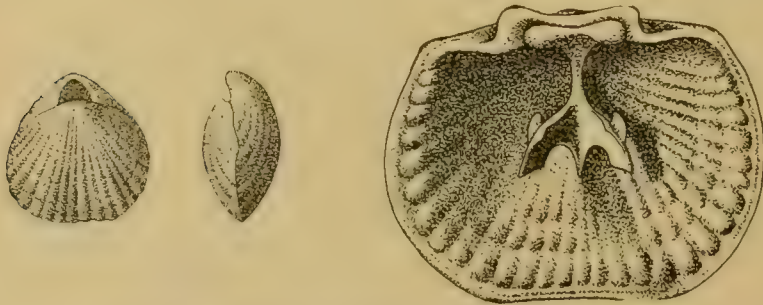
form a ring whose anterior margins are fimbriate and are produced into two fimbriate anterior extensions.

Type, *Ismenia pectunculoides*, Schlotheim (sp.).

Distribution. Jurassic.

Megerlina, Deslongchamps. 1884.

Shells exteriorly as in *MÜHLFELDTIA*; the loop, however, differs in the abbreviation of the descending lamellæ, the anterior portions being attached to the median septum, and the crural pro-



FIGS. 617-619. *Megerlina Lamarckiana*, Davidson (sp.). (DAVIDSON.)

cesses not united. The anterior attachment of the ascending lamellæ to the septum is also modified or incomplete.

Type, *Megerlina Lamarckiana*, Davidson (sp.).

Distribution. Recent (South Africa and Australo-Zealandian Provinces).

Bouchardia, Davidson. 1849.

Synonym; *Pachyhryncus*, King, 1850.

Shells elongate-oval; surface smooth. Beak of the pedicle-valve elevated, subacute, truncated by a circular foramen. Deltidial plates coalesced, concave. Interiorly both valves much thickened in the umbonal region. Teeth and sockets much abbreviated. In the pedicle-valve the adductor and diductor scars are situated anteriorly and divided by a low median ridge.



FIGS. 620-622. *Bouchardia rosea*, Mawe (sp.). (DAVIDSON.)

In the brachial valve is an elongate rectangular, bilobed cardinal process, which fits into the deep pedicle-groove of the opposite valve. Median septum developed anteriorly. Brachidium without the descending branches; ascending branches represented by two broad, curved triangular processes coalesced with the septum below and not uniting above.

Type, *Bouchardia rosea*, Mawe (sp.).

Distribution. Recent (Caribbean Province).

Magas, Sowerby. 1816.

Shells small, subplano-convex. Surface smooth. Pedicle-valve deep, with incurved umbo. Foramen subtriangular, deltidial plates feebly developed. Brachial valve with a well-developed cardinal process, and very prominent median septum. Descending branches of the loop joined to the walls of this sep-

tum; above their insertion arise the ascending processes which are broad, concave, triangular plates, with their apices tapering backward but not uniting.



FIGS. 623-626. *Magas pumilus*, Sowerby. (DAVIDSON.)

Type, *Magas pumilus*, Sowerby.

Distribution. Cretaceous.

Rhynchora, Dalman. 1828.

Shell elongate-ovate, coarsely plicate. Hinge-line short, straight. Foramen large, subcircular, deltidial plates wanting. Teeth, sockets and cardinal process well developed. A low median septum in each valve. Loop not known.

Type, *Rhynchora costata*, Wahlenberg (sp.).

Distribution. Cretaceous.

Rhynchorina, Ehlert. 1887.

Shells small, transverse, the hinge line, which is straight, making the greatest diameter of the valves. Umbones very depressed. Surface smooth. Teeth and sockets placed at the cardinal extremities. Brachial valve with a broad cardinal plate or area extending for the entire length of the hinge; at its center is a callosity or cardinal process, which is supported by a median septum. Loop like that of *MAGAS*.

Type, *Rhynchorina spathulata*, Wahlenberg (sp.).

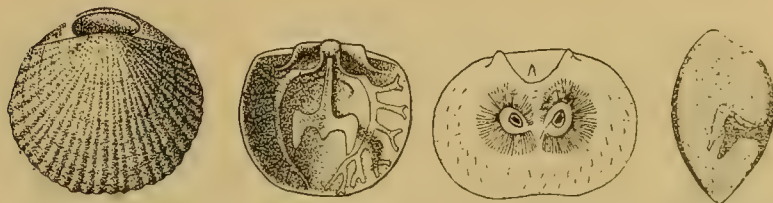
Distribution. Cretaceous.

Kraussina, Davidson. 1859.

Synonym; *Kraussia*, Davidson, 1852.

Shells biconvex, plicate, subcircular or oval; hinge-line straight; foramen large, deltidial plates incomplete. Interior of the brachial valve with cardinal process and median septum. Brachi-

dium reduced to two lateral expanded processes arising from the elevated anterior portion of the septum and representing the ascending process.



FIGS. 627-630. *Kraussina rubra*, Pallas (sp.). (DAVIDSON.)

Type, *Kraussina rubra*, Pallas (sp.).

Distribution. Recent (South African and Australo-Zealandian Provinces).

Mannia, Dewalque. 1874.

Small magadiform shells, with the brachidium consisting of two descending processes, not uniting with the median septum, the latter bearing at its extremity two disunited lamellæ which represent the ascending branches.

Type, *Mannia Nysti*, Dewalque.

Distribution. Miocene.

Platidia, Costa. 1852.

Shells small, biconvex, smooth, with large punctures. Foramen large, encroaching on both valves; no deltidial plates. Teeth and sockets small. In the brachial valve the median septum is reduced to a vertical plate which rises near the center of the



FIGS. 631-633. *Platida anomioides*, Scacchi. (DAVIDSON.)

valve. To this plate the descending branches of the loop are united; ascending branches not represented; brachia in three lobes, the median lobe surrounding the oral orifice and not spirally coiled.

Type, *Platidia anomioides*, Scacchi (sp.).

Distribution. Recent (Lusitanian, Californian, Magellanian, Caribbean and Transatlantic Provinces).

Megathyris, d'Orbigny. 1847.

Synonym; *Argiope*, Deslongchamps, 1842.

Shells transversely elongate; hinge-line long and straight, equaling the greatest diameter of the valves. Cardinal area well developed on both valves. Foramen



FIGS. 634, 635. *Megathyris decollata*, Chemnitz (sp.). *n*, foramen; *o*, deltidial plates; *g*, crura; *l*, lobed extension of brachial supports. (BRONN)

large, oval, deltidial plates small. In the pedicle-valve there is a median septum and two low lateral septa.

Brachial valve with prominent cardinal process, and three or five septa lying in front of the visceral region.

Of these, one septum is median.

Brachidium consisting of a simple continuous lamellæ with broad oral processes and divided into four lobes by the median and first pair of lateral septa. The brachial disk is likewise divided into four lobes.

Type, *Megathyris decollata*, Chemnitz (sp.).

Distribution. Jurassic—Recent (Lusitanian Province).

Cistella, Gray. 1850.

Exteriorly like MEGATHYRIS. Interior of the valves with median but no lateral septa. Brachial lamella bilobed by the median septum to which it is partially attached.



FIGS. 636-638. *Cistella cuneata*, Risso (sp.). DAVIDSON.

Type, *Cistella cuneata*, Risso (sp.).

Distribution. Cretaceous—Recent (Boreal, Lusitanian and Caribbean Provinces).

Zellania, Moore. 1854.

Shells minute, subtriangular, impunctate. Hinge-line short, straight, with cardinal area on each valve. Foramen large, encroaching on the brachial valve. Median septum in each valve. In the brachial valve is a broad pustulose marginal area,



FIGS 639, 640. *Zellania Davidsoni*, Moore. (DAVIDSON.)

the inner edge of which is thickened into a ridge, bilobed by the median septum.

Type, *Zellania Davidsoni*, Moore.

Distribution. Lias.

Gwynia, King. 1859.

Shell thin, minute, biconvex, elongate-oval. Hinge-line short, nearly straight. Foramen large, with incomplete deltidial plates. Interior without septa or loop. Brachia forming an uninter-



FIGS. 641, 642. *Gwynia capsula*, Jeffreys (sp.). (DAVIDSON.)

rupted circlet, the anterior cirri of which are but slightly developed.

Type, *Gwynia capsula*, Jeffreys (sp.).

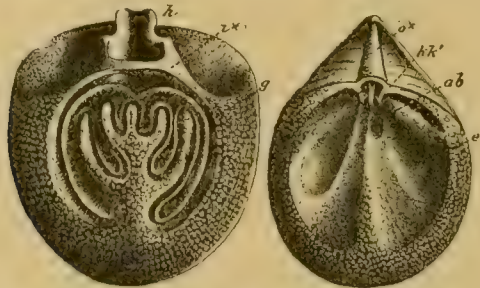
Distribution. Recent (Lusitanian Province).

Thecidea, DeFrance. 1822.

Synonym; *Thecidium*, Sowerby. 1824.

Shells plano-convex, elongate-oval; surface covered with radiating rows of granules. Pedicle-valve with elevated beak,

which is somewhat incurved over the broad, arched cardinal area. Deltidium conspicuously developed. Interior of both valves with broad, thickened granulose marginal areas. In the pedicle-valve the teeth are small and parallel; the adductor muscles rest upon a short median plate lying directly in front of the deltidium, at each side of which is the transversely oval scar of the diductors. Visceral area large, smooth and divided medially by a granulated



FIGS. 643, 644. *Thecidea radiata*, o, deltidium; kk, teeth; ab, adductors, e, diductors; h, cardinal process; i, cardinal plate; g, brachial supports. (Suess.)

ridge. In the brachial valve the cardinal process is large, erect and subtriangular. The median septum branches repeatedly from its posterior extremity forward, and this forms a series of depressions or grooves of unequal length in which lay the lobes of the brachia.

Type, *Thecidea papillata*, Schlotheim (sp.).

Distribution. Cretaceous.

Subgenus *Lacazella*, Munier-Chalmas. 1880.

Shells subtrigonal, solidly attached by the apex of the pedicle-valve; surface smooth or with concentric growth lines. Pedicle-valve with conspicuous cardinal area and deltidium; muscular plate concave, small, free at its anterior extremity. In the brachial valve the cardinal process is strong, subrectangular, concave toward the base, and projected beyond the hinge. The cavities of the brachial lobes in two or three unequal pairs.

Animal with short alimentary canal; embryos developed in a pouch or marsupium situated at the bottom of the pedicle-valve, and attached to the brachia by a pair of long cilia.

(Type, *Lacazella Mediterranea*, Risso (sp.). Recent (Mediterranean); Fossil; Jurassic.—Tertiary.)



FIGS. 615, 646. *Lacazella Mediterranea*, Risso (sp.). (DAVIDSON.)

Subgenus *Thecidiopsis*, Munier-Chalmas. 1887.

Interior of the brachial valve bearing a median septum with many branches and simple lateral marginal septa. Internal surface, septa and brachial lamella covered with granulations.



FIGS. 647-649. *Thecidiopsis digitata*, Sowerby (sp.). (QUENSTEDT.)

(Type, *Thecidiopsis digitata*, Sowerby (sp.). Cretaceous.)

Subgenus *Thecidella*, Munier-Chalmas. 1887.

Shells subtrigonal, generally transverse; with straight hinge-line, well-developed cardinal area and deltidium. In the brachial valve the median septum is broad, elevated on its lateral

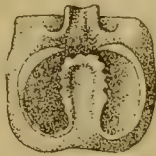


FIG. 650. *Thecidella Normaniana*, Munier-Chalmas. (EHLERT.)

margins, concave on its upper surface and irregularly perforated. Lateral lobes of the brachial lamellæ simple.

(Type, *Thecidella Normaniana*, Munier-Chalmas. Lias.)

Eudesella, Munier-Chalmas. 1880.

Shells transverse, with long, straight hinge. Cardinal area and deltidium well developed. Pedicle-valve moderately deep;

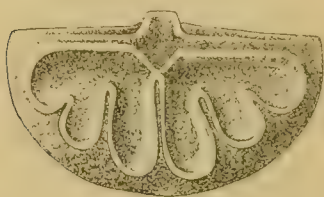


FIG. 651. *Eudesella Mayalis*, Deslongchamps (sp.) (EHLERT.)

muscular scars posterior and thickened. Divisions of the internal surface corresponding to those of the opposite valve. Brachial valve flat; cardinal process prominent, subrectangular. Median septum extending from the anterior

border to the cardinal region; two shorter lateral septa lie on each side. Brachial lamellæ following the lobes formed by the septa.

Type, *Eudesella Mayalis*, Deslongchamps (sp.).

Distribution. Lias.

Bactrynum, Emmrich, 1855.

Synonym; *Pterophloios*, Gümbel. 1861.

Shells elongate, plano-convex; attached by the apex of the pedicle-valve. Surface smooth or with concentric striæ. Shell substance punctate. Pedicle-valve highly convex.

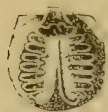


FIG. 652. *Bactrynum Emmrichi*, Gümbel. (HERNES)

On the interior is a low median septum in the umbonal region. In the brachial valve the cardinal process is well developed. The median septum begins near the anterior margin of the shell and extends backward almost to the base of the cardinal process. On each side are from eight to ten short transverse or convergent septa, together forming

a series of lobes which are bounded by the brachial lamella.

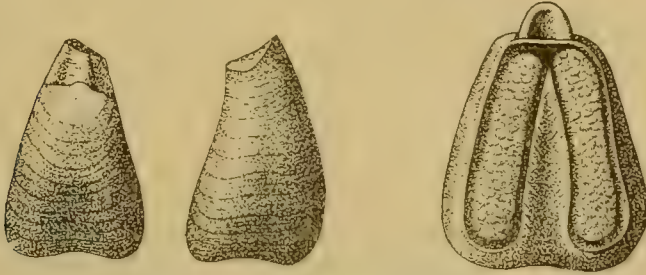
Type, *Bactrynum Emmrichi*, Gümbel (sp.).

Distribution. Lias.

Davidsonella, Munier-Chalmas. 1880.

Shells small, plano-convex, elongate or subquadrangular; attached by the umbo of the pedicle-valve which may thereby become deformed or truncated. Cardinal area and deltidium well developed. Pedicle-valve with two strong, approximate teeth; subcardinal muscular plate divided by a vertical lamella

and supported by a median septum. In the brachial valve the cardinal process is prominent, concave on its inner surface and lies in the plane of the valve. The median septum is broad, acute at its anterior extremity. Between each of its lateral walls and the marginal border of the valve are elongate depressions filled with a loose tissue of calcareous spicules.



FIGS. 653-655. *Davidsonella sinuata*, Deslongchamps (sp.). (DESLONGCHAMPS.)

Type, *Davidsonella sinuata*, Deslongchamps (sp.).

Distribution. Lias.

Lyttonia, Waagen. 1883.

Shells of great size, highly inequivalve and very irregular; frequently with broad lateral expansions.

Pedicle valve convex, thick; apex not distinct; hinge-line short and straight; teeth faintly developed. On the interior are numerous ridges extending in slight curves toward the lateral margins; in the median line a smooth space bearing a central vertical ridge. Brachial valve operculiform, not extending to the margins of the opposite valve. Cardinal process small and

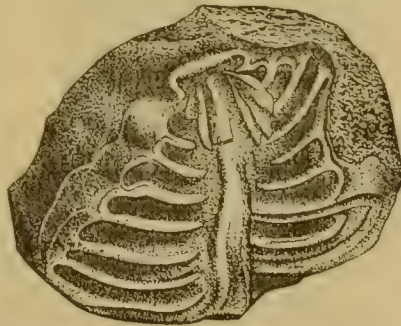


FIG. 656.

Lyttonia nobilis, Waagen.

FIG. 656. Cardinal part of a pedicle valve; showing the hinge-line, median and lateral septa. (WAAGEN.)

bilobed; median surface of the interior with divergent grooves corresponding with the ridges of the other valve.

External surface covered with flexuous lines of growth.

Shell-substance punctate in the inner layers.

Type, *Lyttonia nobilis*, Waagen.

Distribution. Carboniferous.

Oldhamina, Waagen. 1883.

Shells highly concavo-convex.

Pedicle-valve subhemispherical; apex incurved, at maturity covered by a callosity, as in *BELLEROPHON*; attached by cementation in early growth. Hinge-line short and straight, not interrupted in the middle; below it lie well-developed teeth. Interior surface of the valve covered with diverging lateral ridges.

Brachial valve concave. Cardinal process inconspicuous, quadripartite at the summit; continuous with a median ridge extend-

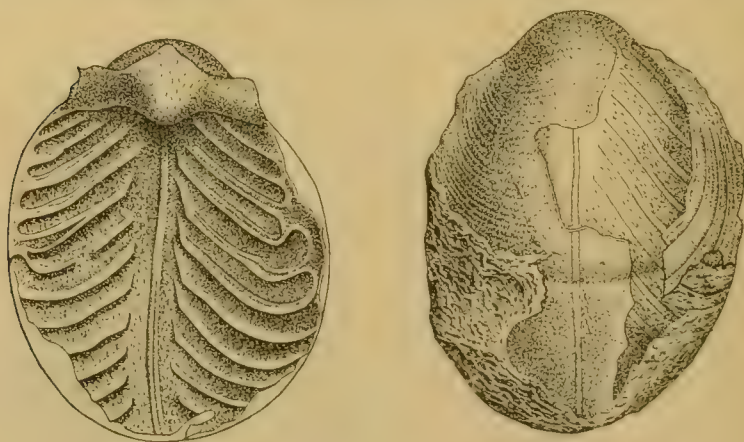


FIG. 657.

FIG. 658.

Oldhamina decipiens, de Koninck.

FIG. 657. The interior of a pedicle-valve; showing the median and lateral ridges.

FIG. 658. The exterior of a pedicle-valve with the shell partly exfoliated. (WAAGEN.)

ing the entire length of the valve. Internal surface covered with divergent grooves corresponding to the ridges of the opposite valve.

Exterior smooth or with numerous concentric lines of growth.

Type, *Oldhamina decipiens*, de Koninck (sp.).

Distribution. Carboniferous.

Eichwaldia, Billings. 1858.

(Plate 54, figs. 12-22.)

Shells subtriangular in outline, with biconvex valves, the pedicle-valve having a broad median sinus, and the brachial valve a corresponding median fold. The umbo of the pedicle-valve is acute and arched over the opposite valve, though not closely appressed against it. As far as has been ascertained, the umbonal space between the two valves is open, that is, there is no deltidium or pair of deltidial plates extending from the apex down-

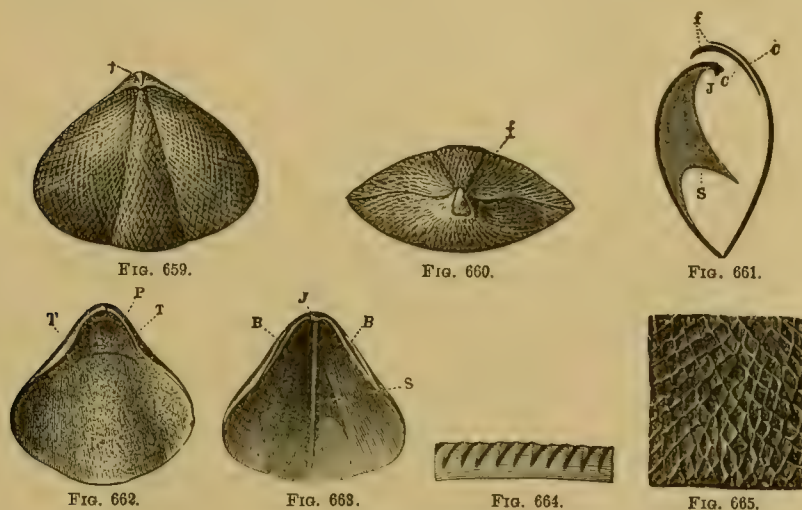
*Eichwaldia reticulata*, Hall.

FIG. 659. Dorsal view.

FIG. 660. Cardinal view.

FIG. 661. Longitudinal section of two valves.

FIG. 662. Interior of pedicle-valve.

FIG. 663. Interior of brachial valve.

FIG. 664. Vertical section of shell.

FIG. 665. Enlargement of the surface.

Notation: *f*, "bare spot" or foramen; *P(c)*, deltidium or internal plate; *c'*, umbonal surface of pedicle-valve; *T*, teeth; *B*, dental sockets; *J*, cardinal process; *s*, median septum of brachial valve.

ward; but there is a short triangular plate or diaphragm which begins at the apex of this valve and extends forward beyond the posterior edge of the brachial valve, and thus serves the purpose of the deltidium, though deeply depressed within the cavity of the pedicle-valve. This diaphragm is usually quite short and confined to the apical region, but it may extend for fully one-fifth the length of the valve, its anterior margin being free and its lateral margins adherent to the inner cardinal slopes. The

cardinal line may be regarded as extending nearly to the lateral extremities of the valves; the articulating apparatus consisting of a pair of long marginal ridge-like teeth on the divergent cardinal slopes, fitting into narrow marginal grooves on the brachial valve. There is sometimes a trace of a median septum over the pallial region. In the brachial valve is a small callus, boss or cardinal process lying directly beneath the apex. Below this is a strong median septum, which increases in height anteriorly and rises to an acute, anteriorly directed apex at about two-thirds the length of the shell. In front of this point its anterior edge is concave, the septum disappearing not far within the margin of the valve.

No traces of muscular scars have been observed on either valve.

The external surface of the valves is covered by a coarse network of superficial cells, usually hexagonal, sometimes circular in outline. In all species and in early growth-stages there is a bare, smooth triangular area at the beak of the pedicle-valve, where this superficial ornament does not extend.

Type, *Eichwaldia subtrigonalis*, Billings.

Distribution. Lower Silurian — Lower Devonian.

Aulacorhynchus, Dittmar. 1871.

(Plate 54, figs. 23, 24.)

Shells short, transversely elongate or alate; extremities often rounded; hinge-line straight, usually making the greatest width of the shell. Valves very thin and fragile. Pedicle-valve slightly convex, with traces of a broad, obscure median sinus; brachial valve flat. Surface covered with numerous regular and continuous, concentric rounded folds or ridges which are separated by furrows of equal width.

In the pedicle-valve the character of the articulating processes has not been fully ascertained. There appears, however, to have been no cardinal area, and but exceedingly small teeth, judging from the structure of the brachial valve. Just within the apex of the valve, which is closely appressed against the opposite one, begins a pair of divergent, elevated ridges, which extend for one-third, or even one-half the length of the shell, and inclose a thickened area or platform, which terminates abruptly in a transverse anterior margin. This platform is the seat of the adductor

and divaricator muscles, and probably rests upon the bottom of the valve and is not vaulted.

In the brachial valve there is a prominent cardinal process from the base of which diverge two lateral ridge or socket walls, lying just within the hinge-line; behind them are linear depressions or dental sockets. There is also a low median ridge extending from the base of the cardinal process into the pallial region.

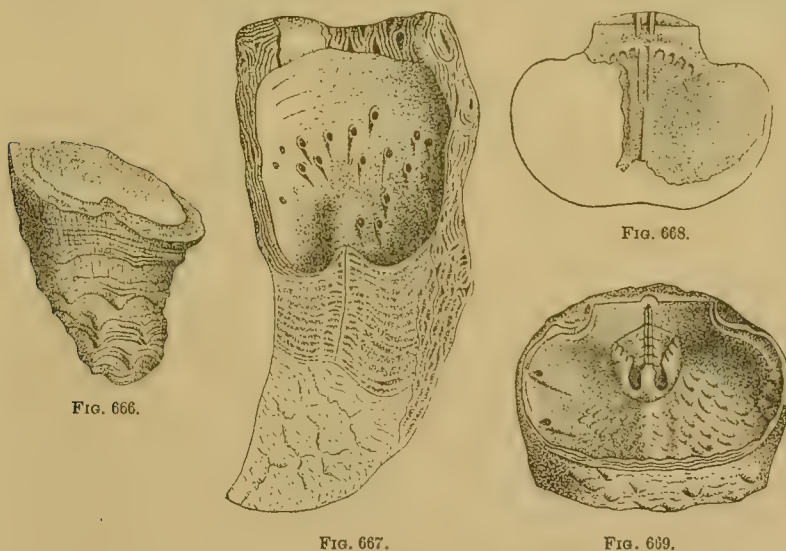
The substance of the shell shows a coarsely prismatic cellular structure, as in *PORAMBONITES* and *EICHWALDIA*. According to BARROIS, this cellular lamina is not superficial but is covered by a thin epidermal layer.

Type, *Aulcoryhynchus Pacht*, Dittmar. Carboniferous limestone.

Distribution. Carboniferous.

Richthofenia, Kayser. 1881.

These peculiar fossils, which bear a striking external resemblance to certain operculated corals, and present some suggestive



Richthofenia Laurenciana, de Koninck.

FIG. 666. The exterior of the two valves in articulation.

FIG. 667. Longitudinal section of the pedicle-valve; showing the interior cavity and the cellular shell substance.

FIG. 668. The interior of the pedicle-valve; showing the hinge-line and muscular scars.

FIG. 669. The interior of the brachial valve.

(WAAGEN.)

similarities to the lamellibranchs *HIPPURITES* and *RADIOLITES*, have been carefully elaborated by WAAGEN, who arrives at the

conclusion that they are of brachiopodous nature, the normal brachiopod characters being somewhat obscured by their mode of growth. From the accompanying figures, taken from WAAGEN'S illustration of the genus, it appears that the valves when well preserved show a distinct hinge-line, faint articulating processes and muscular impressions, all more similar to the corresponding structure in the brachiopods than to anything occurring among the corals or RUDISTA. If this evidence of the brachiopodous nature of these fossils prove convincing, the remarkable development of the cellular testaceous tissue of the pedicle-valve, which produces the striking external resemblance to a coral, is certainly a no more extreme deviation from the brachiopod-type than are such bodies as HIPPURITES, CAPROTINA, RADIOLITES, etc., from the type of lamellibranchiate structure. The shells were evidently attached by solid fixation at the apex of the pedicle-valve, and this attachment strengthened by the epithecal rootlets extending downward from the walls of the valve, similar to those in OMPHYMA and other corals.

Type, *Richthofenia Sinensis*, Kayser.

Distribution. Carboniferous.

The Evolution and Classification of the Genera of the Brachiopoda.

In the foregoing pages, a consecutive account of the characters of the various genera of the Brachiopods has been given, without attempting to interrupt it with broader designations and groupings. In a work of this nature, such a consecutive narration of the genera is necessary, though wholly conventional and unnatural. The development of these animals throughout geologic time has not been along an undeviating line, but, on the contrary, is a series of departures at different periods in their history, from various comprehensive and prolific stocks. The courses of their existence can be expressed only by divergent and ramifying lines branching off here and there at rapid intervals during the vigor of the race, the off-shoots becoming more and more unlike as their growth continues, at times terminating abruptly as though unfavorable conditions had put a period to their existence, but usually in their prolonged existence and gradual decline resuming many of their early parental traits.

As a preliminary and general principle, it must first be observed that, in the development of any great race of organisms (always exemplified by those whose history is known for such an illimitable period as the Brachiopoda) the specialization of generic characters and the evolution of distinct generic stocks is carried on with much greater rapidity during their early existence than at any time in their later history. The primitive types embody the potentialities of all subsequent expressions which the race assumes.

It then becomes a question of elementary importance to ascertain these primitive generic types and to fix upon the radicle or root-stock from which all lines of evolution in this group have departed. With our present knowledge, it is believed possible to approximate these starting points in the history of the race with some degree of accuracy. Before, however, proceeding to

this point, it is important to first consider the basis of a classification and the significance of certain structural features. We have come, in our study of these creatures, very close to the point where any grouping of genera into families, or of these into broader divisions, is so palpably a violation of nature's method as to make itself felt as an incumbrance. Hence the purpose of our treatment of these genera without such restrictions. Even among the generic groups there is so often an almost intangible transition from one to another that the employment of distinctive terms seems at times quite perfunctory; but with the increase of such difficulties the nearer our classification may be regarded as approaching the true method of development. To us the genus represents a structural unit, a point of departure; species, diverse expressions of the generic type; families, associations of genera representing the offspring of common parentage.

A classification is a broken and punctuated expression of organic affinities and interrelations, necessary to an easy treatment of any group of organisms, capable of expressing many truths in regard to the development of a race, but even in its most perfect state an index and confession of faulty knowledge.

In the earlier classifications of the Brachiopoda a high value has been ascribed to the disposition of the muscular scars upon the inner surfaces of the valves, the form of the genito-vascular sinuses and the configuration and degree of calcification of the brachia. To the last of these must still be ascribed a high degree of significance notwithstanding the fact that in the individual this calcification is a progressive process, increasing in extent from infancy to maturity. The plan of the muscular and vascular anatomy is, however, among the Articulate Brachiopods, but slightly modified through their history and in all their variations, but in the Inarticulate division we find it to be susceptible of a more varied expression.

But it is the variation of form, position and mode of enclosure of the pedicle-passage that affords the most satisfactory index of lines of progress and development. We have already briefly referred to, and described the principal modifications of these parts, but a restatement of these structural details is essential to our purposes.

In the chapter upon the "Development of the Shell" it has been shown that the *deltidium* and *deltidial plates*, though similar in function, are profoundly distinct both in origin and structure. The former is primitive and fundamental, the latter wholly secondary; a replacement of, but never a derivative from the former. They may resemble each other, as the so-called *pseudodeltidium* of CYRTINA is externally like the true *deltidium* of CLITAMBONITES, STROPHOMENA and RAFINESQUINA, but this is purely a superficial similarity. The *pseudodeltidium* consists, in its early condition, of discrete *deltidial plates* and in its mature state it expresses simply a firm coalescence of those plates. The term *pseudodeltidium* is a convenient one to employ for this peculiar phase of the *deltidial plates*; but we have proposed to distinguish the latter generally by the use of the term *deltarium* in application to the parts as a whole, whether coalesced (CYRTINA, NUCLEOSPIRA, REYZIA, etc.), or discrete, and *deltaria* in referring to the component plates. The reader is again referred to the chapter already cited for the full explanation of the differences in the *deltidium* and *deltarium* as worked out by BEECHER, in which it is demonstrated that the former is, in a certain sense, a *third valve*, not forming on the mantle lobes of the young as do the true valves, but upon the body of the embryo, enclosing the cardinal space between the latter. This solid, continuous, never divided plate or pedicle-sheath remains throughout all growth-stages in a large division of the Articulate genera mostly of early age; while in a coextensive group predominating throughout the later history of the class, this primitive structure is resorbed at an early stage of growth, and the enclosure of the pedicle effected by the formation of discrete secondary plates which originate from the mantle lobes and not from the body of the shell.

The term *spondylium* has been applied to the spoon-shaped plate which frequently occurs in the pedicle-valve of many of the Articulates (PENTAMERUS, CLITAMBONITES). A plate of similar character appearing in the brachial valve of the same groups of genera has been referred to under the same name, but it is found that these plates in the different valves are similar neither in origin or function; hence that of the brachial valve is now distinguished by the term *cruralium*. In the Inarticulate Brachio-

pods there are internal structures which seem to have served similar functions to the spondylium and cruralium of the Articulates. These occur in the genera *LINGULASMA*, *TRIMERELLA*, *DINOBOLOS*, and all the genera constituting the group termed by DAVIDSON and KING, the *TRIMERELLIDÆ*; and have been known as the *platforms*. Though all these structures have manifestly subserved the same purpose to the animal their origin is due to unlike causes though their growth was aided by similar conditions; hence they are not strictly homologous parts.

The *spondylium* is an area of muscular implantation. It is derived from the convergence and coalescence of the dental lamellæ and forms a receptacle primarily for the proximal portion of the pedicle and for the capsular or pedicle-muscles and eventually for all the muscles attached to the valve. For the inception of the platform on the pedicle-valve of the Trimerellids it is not so easy to assign an explanation, but its beginning once made, there seems no reason to doubt that the increase in size and prominence both of platform and spondylium has been greatly aided by the crowding of the essential organs of the animal about and beneath these muscular plates (see pp. 193, 194).

Considering the spondylium in its elementary condition where, as in *ORthis*, it is represented only by the convergent dental plates uniting with, or resting upon the bottom of the valve, enclosing only the base of the pedicle and its muscles, it becomes evident that the plate is actually but a modification of the original pedicle-sheath. It is the inner moiety of this sheath surrounding the pedicle, which has become involved in or enclosed by the growth of the pedicle-valve, and further modified by the development of articulating processes where it comes in contact with the brachial valve. It may, therefore, be inferred that wherever the spondylium is present, whether in the incipient condition or in the more advanced stage of development in which it supports all the muscles of the valve, it is or has, at some period of growth, been accompanied by the external portion of the sheath which is termed the deltidium. Thus the spondylium appears to be but the complement of the deltidium, and that the two were together included in the original

or primitive deltidial plate formed upon the body of the embryo (prodeltidium).

The transverse plate or *platform* in the *brachial* valve of the Inarticulates is evidently homologous in origin and function with that of the pedicle-valve in the same group. On the other hand, the spoon-shaped process or *cruralium* in the brachial valve of the Articulates (PENTAMERUS, etc.), is a totally different structure from the spondylium, similar in function but of more fugitive valve. It has originated from the convergence and union of the crural plates, and it may, like the spondylium, rest upon the inner surface of the valve or be supported by a median septum.

The *cardinal area* is a feature of which we find a trace spasmodically among the Inarticulates, and, in the Articulates, is more generally developed in the deltidium-bearing genera, though it may be said that in this group also it is very irregular in its appearance. The genus SPIRIFER furnishes a striking instance of its persistence in the deltarium-bearing shells. It is probable that the existence of this area has little fundamental connexion with the condition of the pedicle-coverings. It is a very palpable fact that there is a much more intimate relation between this area and the general form of the shell; thus in the elongate shells like the terebratuloids, meristoids, retzioids and the pentameroids for the most part, there is no such area present. Where the form of the shell is more generally transverse as among the ORTHIDÆ, in STROPHOMENA, CLITAMBONITES, DERBYA, SPIRIFER, etc., the area is highly developed.

It has been suggested that this area may have originated in an obstruction to the peripheral growth of the valves upon their posterior margins, and would, therefore, be greatest in shells whose pedicle was short and necessitated a close attachment (see pp. 155, 163).

In this presentation of the characters of the generic groups, the genus LINGULA has been taken as a starting point, more for the reason that it is a widely distributed and well-known type than because we have any reason to regard it as primitive.

The nearest approach to the radicle of the entire class is expressed by the genus PATERINA, Beecher (p. 247), which bears at maturity the form and structure of the primitive shell or protegulum. It is orbicular in form, with a straight or arcuate

hinge-line and no cardinal area. The pedicle-opening is a broad triangular fissure, the valves being in contact behind only at and near the cardinal angles. Though this shell is from the Lower Cambrian faunas there are other brachiopods of obolelloid type that are quite as ancient; still *PATERINA* exemplifies the source from which the development of more complicated forms has proceeded.

From this simplest of all known (and it might be fair to say, all possible) brachiopods, the development and specialization of generic characters proceeded in various directions. The orbicular form and preponderating chitinous shell-substance form essential traits of a considerable group of primeval genera represented by *OBOLUS*, *OBOLELLA*, *ELKANIA*, etc., in which, however, decided progress is evinced in the rapid specialization of the muscular apparatus as well as in the restriction of the pedicle-passage to a narrow slit. Some closely allied forms with highly chitinous shell and obolelloid * muscular scars present an elongate rather than subcircular outline, and in this respect indicate a departure toward the characteristic linguloid exterior. This is first shown by the Cambrian and early Silurian genera *LINGULELLA*, *LINGULOPS* and *LEPTOBOLUS*.

The true *LINGULA*, with its highly complicated muscular apparatus, appears to have become established and static some time after the opening of the Silurian (Trenton fauna) and we have no reason for believing that the type of structure fixed at that remote period differs essentially from the typical *Lingulas* of existing seas. It is not that offshoots and modifications were not given off, especially during the early periods of its existence, but such lateral departures were short-lived and the old firmly established generic type, resistant to variation in physical surroundings or adapted to the whole vicissitude of marine conditions, has perpetuated itself without modification as far as indicated by the structure of the shell.

GLOSSINA, *DIGNOMIA*, *BARROISELLA* and *TOMASINA*, which represent early deviations from *LINGULA* during the Silurian and Devonian periods, embody no substantial variations, though the last two demonstrate a gradual assumption of articulating processes.

* *OBOLELLA* is a more elementary type than *OBOLUS*, as is strongly evinced by the character of the muscular scars. In *OBOLUS* the latter are complicated and approach those of *LINGULA*.

The purely conventional value of family designations could not be more forcibly illustrated than among the groups now under consideration, and as shown by the following facts: Among the *Obolidae* there is, in a certain direction, a tendency manifested toward the formation of a thickened muscular platform, a structure to which we have already referred as being most highly developed in the trimerellids (*Trimerella*, *Dinobolus*, etc.). This is seen in the Cambrian genus *Elkania*, where these platforms are solid muscular thickenings of the shell, and their development is more highly advanced in *Lakhmina*, also of Cambrian age, in which the platforms are vaulted or excavated beneath. *Dinobolus*, which makes its appearance in the early faunas of the Silurian (Black River limestone), is a large shell of oboloid exterior and having these platforms well developed, sometimes solid, but often excavated. This genus continues its existence or rather, in accordance with our knowledge, reappears after a long interval, in the later faunas of the Upper Silurian in a fuller manifestation and in association with other platform-bearing genera, *Trimerella*, *Monomerella*, *Dinobolus*.

Among the *Lingulidae* a similar tendency to the formation of these platforms manifests itself, though at a later period than in the oboloids. The elementary condition of development is expressed in *Lingulops*, and in a more advanced stage in *Lingulasma*, of the middle Silurian. In *Trimerella*, *Monomerella* and *Rhinobolus* of the later Silurian the linguloid form of the shell is retained and the highest stage of platform development attained. These shells have been closely studied; our knowledge of them is fairly complete, sufficient to justify us in the conclusion that in the *Trimerellidae* (of *Davidson* and *King*; a very natural group, including *Trimerella*, *Monomerella*, *Rhinobolus* and *Dinobolus*, to which we should add *Lingulops* and *Lingulasma*), the derivation of the platform has been along two distinct and convergent phyletic lines, one departing from the oboloids, the other from the linguloids. The line of the platform bearing Inarticulates ends abruptly and finally with the close of the Silurian. The tendency to produce these platforms, which was then common to the oboloids and linguloids, and hence a heritage from common ancestry fails to manifest itself in other lines of departure

Some of the accessory causes contributing to the production of the vaulted plates seem to have been efficient at various times throughout the history of the entire class, and we find them manifested in the Articulate Brachiopods by the marginal elevation of the muscular area in *DOUVILLINA* and *LEPTENA*; they probably also served to render more complete the isolation and perfection of the spondylium, but the true platform does not again appear. (For suggestions as to the organic causes of such elevations see p. 194.) With the knowledge of so many transition genera between the oboloids and linguloids and trimrerellids, it is a pure convention to accord recognition to the families *OBOLIDÆ*, *LINGULIDÆ* and *TRIMERELLIDÆ*.

This entire group of genera is characterized by the presence of an unenclosed marginal pedicle. They compose the *MESOCAULIA*- or *LINGULACEA* of *WAAGEN* (*ATREMATA* of *BEECHER*).

The second main division of the Inarticulate genera is composed of those in which the pedicle-aperture, in immature stages or in primitive adult conditions takes the form of a marginal incision of the pedicle-valve, but becomes enclosed in the shell-substance in later stages of growth. To this group *Waagen* applied the term *DIACAULIA** or *DISCINACEA* (1883).

In the genus *ORBICULOIDEA*, early stages of the shell have the pedicle-passage or open triangular incision extending with widening margins from the apex of the pedicle-valve to the periphery. With advance of age this passage becomes contracted and normally closed at the posterior margin, and may be variously modified by the deposition of adventitious deposits about it. In the Cambrian genus *DISCINOLEPIS* the open slit is a mature character, and it also appears in several similar genera of later date, sometimes slightly modified, e. g., *TREMATIS*, *SCHIZOBOLUS*, *EHLETTA*, in others quite primitive and unchanged, e. g., *SCHIZOCRANIA*. These are all orbicular and highly chitinous shells; the line along which they have been derived departed at an early period from the radicle stock, apparently attained its diverse variations in Palæozoic time, and has been continued to the present in the most highly modified representatives of the

* This name was originally printed *DAICAULIA*, probably a typographical error in the spelling of the first syllables.

group, DISCINA and DISCINISCA. All these forms are conveniently grouped under the family term *DISCINIDÆ*.

In ACROTRETA, CONOTRETA, LINNARSSONIA, ACROTHELE and IPHIDEA the pedicle-aperture is persistently located at the apex of the pedicle-valve. This group of genera is one of very early date, for the most part contemporaneous with PATERINA, and the existing evidence would indicate that it was not directly ancestral to the line of TREMATIS-ORBICULOIDEA (*DISCINIDÆ*). The incipient formation of an internal foraminal tube is seen in several of these genera (ACROTRETA, ACROTHELE, LINNARSSONIA), and this feature attains its maximum in the true SIPHONOTRETA of the Lower Silurian, where the foramen is still apical and the tube wholly internal. Hence SIPHONOTRETA appears to be a normal termination of this line of descent. SCHIZAMBON, in the comprehensive meaning of the term ascribed to it in this work, has the pedicle-passage superficial, and in such shells as *Schizambon fissus*, Kutorga, and var. *Canadensis*, Ami, the condition of this passage is perfectly analogous to that of SIPHONOTRETA, the entire difference being in the enclosure of the latter. In SCHIZAMBON the fibers of the pedicle, extending through the foramen near the middle of the pedicle-valve, were directed toward the apex of that valve, and along the concave floor of the external pedicle-groove. The inner aperture of the pedicle-tube in SIPHONOTRETA, corresponds to the "foramen" of SCHIZAMBON, and the outer aperture, or true foramen, of the former to the grooved umbo of the pedicle-valve in the latter. Hence in SCHIZAMBON, thus considered, there is no evidence of a progress of the external aperture, or true foramen, anteriorly beyond the apex of the pedicle-valve. These two genera are but slight departures from the same type of structure, but it would appear that this deviation took place during primordial times, as the typical SCHIZAMBON (*S. typicalis*, Walcott) is a primordial fossil. The genus, TREMATOBOLUS, Matthew (*T. insignis*, Matthew, type), appears to be another primordial representative of this structure, with the tubular enclosure of the pedicle more highly developed. Thus all these genera, from ACROTHELE to SCHIZAMBON and SIPHONOTRETA, possess an apical foramen, and the development both of the internal tube and the corresponding external groove has been a gradual one. They represent termini of slightly divergent series, consequently

they may all be safely included under the old family designation introduced by KUTORGA in 1848, *SIPHONOTRETIDÆ*.

CRANIA and its allies (CRANIELLA, PSEUDOCRANIA, PHOLIDOPS) constitute a group in which, thus far, there is no satisfactory evidence of the existence of the pedicle, and we are left to the assumption that this organ became atrophied at a very early growth-stage. The study of recent Cranias has not yet determined this point, but will probably ultimately accomplish this end. At whatever stage of growth the pedicle was lost, we may infer that its disappearance was directly followed, in CRANIA, and generally in CRANIELLA, by a solid fixation of the animal by the substance of one of the valves. In PHOLIDOPS there was no such cementation, but at a correspondingly early stage the shell became wholly independent. All these shells with central or subcentral beaks have an external resemblance to ORBICULOIDEA; the formation of the secondary growth of the valves behind the apices or position of the protoconch, is a further substantial agreement with the DIACAULIA as contrasted with the abbreviated posterior peripheral shell-growth in the MESOCAULIA (LINGULA, OBOLUS). It is nevertheless to be observed that no trace is found on mature or immature shells, of a former pedicle-slit, incision or perforation, and it would be difficult to comprehend in what manner such an essential modification of the shell could be wholly concealed by later growth.* Were the pedicle marginal in primitive growth-stages, and subsequently atrophied, the obliteration of the marginal opening by later resorption and growth would be a readily intelligible process. There is, hence, in this default of evidence, a good reason to doubt the close affinities of CRANIA and PHOLIDOPS to the DIACAULIA. Present knowledge would seem to indicate that they were primarily of the type of the MESOCAULIA, and that their resemblance to the DIACAULIA is wholly of secondary growth.† WAAGEN's term for this group GASTEROPEGMATA (or CRANIACEA), may therefore prove to be equivalent to each of these other two divisions.

* Quite early conditions of *Crania siluriana* and *Craniella Hamiltonia*, from 1.5 to .5 mm. in diameter, are fully cemented. Examples of *Pholidops Hamiltonia*, not above .5 mm. in diameter, give no indication of a pedicle-passage or surface characters not present in the adult.

† Some species of PHOLIDOPS (*P. arenaria*, *P. linguloides*) have a terminal submarginal apex; and their resemblance exteriorly to the oboloids is very striking. This is, however, no more than a resemblance, as they show, on the under side, the same mode of peripheral growth beneath the beak as the other forms of the genus in which the umbones are more nearly central.

The great gulf which has seemed to exist between the Inarticulate or Lyopomatous, and the Articulate or Arthropomatous divisions of the Class Brachiopoda; those without teeth, and those with teeth; those with a largely corneous shell, and those whose shell is essentially calcareous, is not yet fully spanned at many points.

These divisions were based upon the study of living brachiopods in which all the characteristic differences are pronounced and fixed. It is natural, however, to find among the early brachiopods, in which the adjustment of the organism to its conditions was highly sensitive, that the oscillation and specialization of characters has been very rapid. The development of articulating processes has already been noticed among the linguloids in *BARROISELLA*, *TOMASINA* and *TRIMERELLA*, among the oboloids in *SPONDYLOBOUS*, and among the siphonotretoids in *TREMATOBOLUS*. It is known that the shell of many inarticulates is almost wholly calcareous, as in the *TRIMERELLIDÆ*, and all of the *GASTEROPEGMATA*. The alteration in the nature of the shell-substance from the protoconch or its exemplar, *PATERINA*, which appears to be wholly or essentially corneous, to the typical articulate brachiopod, in which the corneous substance is reduced to a thin epidermal film, is a gradual process whose various stages are well understood. In *OBOLUS*, *ELKANIA*, and the early forms of *LINGULA*, the deposition of calcareous salts in the shell was already advanced, these layers alternating with thinner layers of corneous substance. The gradual and eventual predominance of the calcareous shell-matter along both of these lines of development is seen in the ponderous Trimerellids of the later Silurian. The graduation of the corneous *PATERINA* (*Kutorgina Labradorica*, var. *Swantonensis*) through *Kutorgina Labradorica*, and into the true calcareous Kutorginas (*K. cingulata*, *K. Whitfieldi*), is similar evidence. In *Kutorgina Latourensis*, MANTON described a minute tooth on either side of the pedicle-opening, and it has been stated that *K. cingulata* shows faint traces of articulating processes at or near the extremities of the cardinal line. Such cases indicate a direct transgression in the texture and composition of the shell from the most primitive inarticulate type to the articulate. In this feature only, the connection between the two divisions of the class is no closer or more clearly manifested than in the instances mentioned, but it

has been shown that *Kutorgina cingulata* may retain a pedicle-covering or external sheath, in fact a true deltidium bearing an apical perforation, like that in CLITAMBONITES. The same character is highly developed or fully retained at maturity in IPHIDEA. This is evidence of the highest moment, and conclusively shows the line along which the clitambonitoids and strophomenoids have been derived. It is an immediate departure from the primitive type of the brachiopod into the articulate subtype.

Passage from the inarticulate to the articulate plan of structure was thus effected at a very early period; indeed, almost at the outset of the history of the group. The continuance of the two types has since been that of diverging series, constantly widening the structural gap between them. We have no irrefragible evidence that this chasm has been bridged at any other point than near its source; the inclinations from the one type toward the other, shown in the articulating processes of BARROISELLA, TOMASINA, etc., represent uncompleted accessory lines of development, which were abruptly terminated without accomplishing the full transitions. Such forms have left no descendants, so far as known.

The most elementary structure, then, observable, among the Articulate Brachiopods is the combination of the deltidium with a distinct pedicle-cavity, whose anterior margins are not free, and whose lateral walls or dental lamellæ are not highly developed; these features being accompanied by gently and unequally biconvex valves, well-defined cardinal areas and elongate hinge-line; producing, in effect, a generally orthoid expression both of interior and exterior. This is the condition of BILLINGSSELLA of the Cambrian, *Orthis loricula* and *O. deflecta* of the Trenton group, and *O? laurentina* of the Hudson River fauna, and it is continued without essential modification, except in the gradual contraction of the pedicle-cavity and deltidium, into STROPHOMENA of the Silurian, its allies and successors, ORTHOTHETES of the Devonian, and DERBYA of the Carboniferous, HIPPARIONYX, TRIPLECIA, STREPTORHYNCHUS, etc.; into LEPTAENA, RAFINESQUINA, STROPHEODONTA, PLECTAMBONITES, CHONETES and PRODUCTUS.

The tendency to contract the pedicle-cavity and deltidium presents its extreme manifestation in the Devonian forms of

STROPHEODONTA, STROPHONELLA and LEPTOSTROPHIA, where it has become almost, and sometimes quite obliterated, and the entire pedicle and umbonal cavity filled with testaceous secretions. Such filling can occur only in a discarded and useless space, after the pedicle has ceased to be functional. A morphological consideration of much importance presents itself here, as well as in many other groups of genera where the shells attain great size. The evidence is very direct from the study of the structural features as given above, that the entire muscular system on the ventral side of the body is, in primitive forms, inserted upon the base of the pedicle-cavity. This is apparent from a study of such a shell as *Orthis callactis*, where it is perfectly clear that no muscular bands were attached to the pedicle-valve outside the limits of this strong and condensed posterior area, which is but a sessile spondylium. The contraction of this pedicle-cavity is accompanied by (whether in relation of cause to effect may not be stated) a diffusion of the area of muscular attachment, and when the shells are large, as in STROPHOMENA, RAFINESQUINA, STROPHEODONTA, ORTHOIHETES, DERBYA, etc., the necessity for powerful muscles or some similar cause magnifies this expansion of the muscular area until the original contents of the pedicle-cavity may be represented by enormous muscles whose scars extend almost to the anterior margin of the valve, as in HIPPARIONYX and RHIPIDOMELLA.

In this great group of genera there are two types of contour, one, as in LEPTENA, being normally convexo-concave, that is, with the pedicle-valve convex and the brachial valve parallel to it and concave; the other, as in STROPHOMENA, having this contour reversed, the pedicle-valve at first convex, but subsequently and through all later growth-stages concave, while the brachial valve becomes correspondingly convex. In both cases, as in other brachiopods, the primitive and post-embryonic valves are both convex. The peculiar reversal of contour, which is never more extremely manifested than in this group, but nevertheless occurs in other genera, such as ATRYPA, many Rhynchonellas, etc., is a purely secondary condition. Its causes have not been fully investigated, but an unequal peripheral growth of the two valves seems to be a sufficient explanation of its existence. As either the presence or absence of this reversal is a normal secondary

condition, it is not possible to give it great weight in a broader grouping of the genera, for we find that *SIROPHONELLA* is but a reversed *STROPHEODONTA*, passing through similar phases; *AMPHISTROPHIA* is a reversed *BRACHYPRION*, both existing in faunas of the same age, and *STROPHOMENA* is a reversed *RAFINESQUINA*, both similarly coexistent.

With this presentation of the subject it seems neither necessary nor desirable to propose any broad division of this group of genera. In 1846 KING proposed to embrace *STROPHOMENA* and its allies in the family *STROPHOMENIDÆ*. The large number of generic values allied to *STROPHOMENA*, which have been determined since that date, make this comprehensive family divisible *ad libitum*, *sed non in maiorem Dei gloriam*.

The calcareous fixation of the pedicle-valve to extraneous bodies after the closure of the pedicle-passage and atrophy of the pedicle itself, is repeatedly manifested by these shells. This, as already shown, is a pre-adult condition in *ORTHOTRETES*, *DERBYA* and *STREPTORHYNCHUS*, the shell becoming wholly free before full growth was attained; but in *LEPTENISCA* and *DAVIDSONIA* the attachment was maintained throughout the later existence of the shell.

The impressions left by the spiral arms upon the interior of the valves in *DAVIDSONIA* and *LEPTENISCA*, and also observed by DAVIDSON in a specimen of *Rafinesquina Jukesi*, show a complete correspondence in the direction and curvature of the coils, and we are left to infer that other members of the *STROPHOMENIDÆ* were in agreement with this structure, and hence that the arms in their uncalcified condition approached nearer the calcified spirals of *KONINCKINIDÆ* (*CÆLOSPIRA*, *KONINCKINIA*, etc.) than to those of any other group.

The condition of the pedicle-passage possessed by these shells is maintained by *CHONETES* and *PRODUCTUS*, without great modification in other respects. *CHONETES* possesses a marginal row of strong cardinal spines or tubes communicating with the internal cavity of the valves. Yet we are acquainted with forms (*e. g.*, *Anoplia nucleata*) in which these spine-tubes do not manifest themselves externally. *PRODUCTUS* is normally covered with spines on one or both valves, but there are some species which possess none. The cardinal area, deltidium and teeth, which are

retained in *CHONETES*, *PRODUCTELLA*, *STROPHALOSIA* and *AULOSTEGES*, become wholly obliterated in the direct line of productoid development. In all these forms the "reniform impressions" retained on the inner surface of the brachial valve are evidence of fleshy brachia possessing a similar curvature to those of the *STROPHOMENIDÆ*.

This group of genera has long been designated by the family name *PRODUCTIDÆ*, introduced by GRAY in 1840, though, in correlating the various divisions of WAAGEN'S group, *APHANEROPEGMATA*, there would be excellent reason for considering the chonetids and productids components of a subfamily inferior in value to the *STROPHOMENIDÆ* and quantivalent to the divisions *Orthothetinae*, Waagen, 1884, and *Rafinesquininae*, Schuchert (*emendatus*), 1893.

Returning to the point of departure, we shall find that in the genus, *ORTHIS*, which in its broadest significance is tantamount to the family *ORTHIDÆ*, Woodward, 1852, since the elimination of several heterogenous branches, the deltidium was resorbed at an early stage of growth, leaving the delthyrium a wide, uncovered aperture during all the later stages of existence. The pedicle in this group of shells was undoubtedly large and vigorously functional throughout all mature conditions, as it is very rarely that any secretions of calcareous matter are found in the apex of the delthyrium, such as are frequently observed in mature and senile conditions of *SPIRIFER*. The sharp delimitation of the pedicle-cavity containing all the muscular scars of the pedicle-valve, which occurs in the earlier forms (those of *ORTHIS* in its restricted meaning, such as *O. callactis*, *O. costalis*, etc.) is maintained in all the numerous subdivisions of the genus, with the exception of *RHIPIDOMELLA* in which there is a great expansion of the muscular scars, similar to that in the *STROPHOMENIDÆ* and to which reference has just been made. Otherwise the sessile condition of the spondylium is not modified throughout the entire history of this group.

The elevation of the spondylioid plate, or the base of the pedicle-cavity, into a true spondylium is a phenomenon of equally early age to the two conditions already discussed. It appears in a highly-developed state in conjunction with the unmodified deltidium, first in *PROTORTHIS*, of the Cambrian, then in *POLYTRÆ*

CHIA, SYNTROPHIA, CLITAMBONITES and SCENIDIUM of the early and later Silurian and of the Devonian.

A parallel line of development is exhibited by spondylium-bearing forms in which the deltidium disappeared at a very early period, and the shells possess a trihedral, generally coarsely plicated and decidedly rhynchonelloid exterior. It seems highly probable that this line was differentiated in the early Cambrian, as indications of this structure are observable in some primordial species, as *Camarella? minor*, Walcott, and *Stricklandinia? Balclatchensis*, Davidson; in the Silurian it is represented by CAMARELLA and PARASTROPHIA, by the more rotund and more finely plicate shells, ANASTROPHIA, PORAMBONITES, LYCOPHORIA and NÆTLINGIA. The last-named genera are not homogeneous with the others in the phases of development which they represent, all of them retaining the cardinal areas more or less distinctly, while LYCOPHORIA and NÆTLINGIA also possess a cardinal process in the brachial valve. The presence of the cardinal area in such early structures must be regarded as a retention, rather than a resumption of a primitive character.

Whatever may be the oscillation in form and the variation in secondary characters presented by CAMARELLA, PARASTROPHIA and their allies, present evidence indicates that they must be regarded as the genetic precursors, as they are the secular precedents of the great group of true pentameroids (PENTAMERUS, CAPELLINIA, CONCHIDIUM, BARRANDELLA, SIEBERELLA, PENTAMERELLA, GYPIDULA, STRICKLANDINIA, AMPHIGENIA); and, indeed the last of these pentameroids, CAMAROPHORIA, of the Carboniferous and Permian faunas, is an exemplification of, and in fact a return to the rhynchonelloid exterior and the camarellid aspect, with the addition of deltarium in the delthyrium.

While considering in detail the pentameroid genera mentioned above, it has been shown that in certain of them, as PENTAMERUS and CONCHIDIUM, a true deltidium is often retained, though it is a fragile structure rendered concave by the arched growth of the umbones of the valves, and is generally absent. In others, as GYPIDULA and PENTAMERELLA, there are occasional evidences of lateral, erect or convex growths upon the margins of the delthyrium, which may be interpreted either as remnants of a resorbed convex deltidium, or as highly accelerated secondary

deltaria. Every now and then specimens will show a clearly-developed cardinal area; always in *STRICKLANDINIA*, frequently and normally in *GYPIDULA*, rarely in *PENTAMERELLA*. *STRICKLANDINIA* possesses so straight and long a hinge, so sharply defined an area and so short a spondylium, that it is more natural to regard this genus as the accompaniment, rather than the close organic kin of the other pentameroids, deriving its differentials directly from those long and straight hinged shells of the early Silurian, which constitute the genus *SYNTROPHIA*.

It will not now appear a matter of inexplicable aberrancy that the spondylium presents itself in the great secondary groups comprising the rhynchonellids, and those shells with calcified brachidia. Hence we meet with it in *CYRTINA* and *CAMAROSPIRA* in a highly-developed state, and in *CAMAROTECCHIA* in a less advanced condition, while *AMPHIGENIA* presents the remarkable combination of a spondylium coexistent with a shell of completely rensselaeroid aspect (that is, in respect to form, contour, muscular markings and articulating apparatus) and with rhynchonelloid brachial supports.

Attention has already been directed to the fact that some of the *RHYNCHONELLIDÆ*, early in their history, occasionally retain a well-defined cardinal area and that, in default of other evidence, the presence of this character may be regarded as indicative of the common origin of *ORTHIS*, the *STROPHOMENIDÆ*, and the Rhynchonellas. The earliest phyletic stages of the rhynchonellids must have been highly accelerated, for there is no evidence of any form which has shown the slightest trace of deltidium. Nevertheless the early forms of the Silurian, such as *ORTHORHYNCHULA* and *PROTORHYNCHA*, rarely show any indication of deltaria at maturity, but the delthyrium, in its final stage, is unobstructed and simple, as in young conditions of later rhynchonellids in which the deltaria fully develop. We may look upon the *RHYNCHONELLIDÆ* as a family whose characters became established very early and have been perpetuated up to the present without wide departure, at any time, from the early derived type.

In the study of the multifold variations of the articulates bearing calcified spiral brachial supports, the *HELICOPEGMATA* of Waagen (1883), the conclusion has enforced itself that the degree

of solidification of the brachia in this group is to be regarded as an index of differentiation. To illustrate: There is no evidence for assuming that the single revolution made by the spiral in *PROTOZYGA* and *HALLINA* represents an incomplete spiculation of the brachia, or that the spiniform and discrete jugal processes in *SPIRIFER*, persisting throughout the genus, do not fully exemplify the adult condition of the jugum (=loop) in these shells. The mode of spiculation of the brachia in such of the living terebratuloids, in which the solidification is direct or without complicated metamorphoses, is on the whole confirmatory of this inference; but as there is no living representative of the spire-bearing forms evidence in regard to the mode and degree of spiculation in this group to be derived from the existing loop-bearing shells, in which the brachial supports pass through highly complicated metamorphoses, is not altogether germane. In such intricate structures as the brachidia of *ATHYRIS*, *KAYSERIA*, *KONINCKINA*, etc., there can be little doubt that the calcified apparatus represents the full extent of the fleshy brachia simply because, if for no other reason, the further expansion of the brachial lamellæ would not be possible for want of space. Moreover, in the spiculation of the spirals in all these old shells there have been no changes of form in later growth except those proceeding from the normal process of resorption and deposition necessary for increase in size and length. The reason why the spiculation should be complete in the spire-bearing forms, while in the *ANCYLOBRACHIA* or the terebratuloids it does not extend beyond the loop and the lateral extensions of the brachia, but in the *RHYNCHONELLIDÆ* affects only the crura, and in the *STROPHOMENIDÆ* does not occur, even in the most elementary condition, is for future investigations to ascertain.

The form of the paired spirals varies but little except under the necessity of conforming to the interior cavity of the valves. Their inclination and direction is a feature of much significance when considered with reference to the development of the entire shell. It is, however, the loop, or to employ a term more appropriate in view of the homologies of the spire-bearing and loop-bearing shells, the *jugum*, which is subject to the most frequent variations in form, and which serves as the generic index. When the spirals are directed outward toward the lateral margins of the

valves, the jugum seems to be much more variable than in shells where the spirals are introverted or take some intermediate position. In the latter there is a much greater variation in the position of the loop upon the primary lamellæ than occurs in the former.

The earliest spire-bearing shells yet discovered are the simplest, in the structure of the brachidium. *HALLINA*, *PRO OZYGA*, *CYCLOSPIRA* of the Lower Silurian possess brachidia which make a little less than one or two volutions of the calcified lamellæ, with a slight inclination toward each other, and to the median axis of the shell. *ZYGOSPIRA* and *GLASSIA*, the contemporaries and successors of these primitive structures, show progressed conditions of the same form of brachidium. In these genera, however, there is a slight deviation in the vertical axes of the spirals from the transverse axis of the shell, the apices being inclined somewhat toward the brachial valve, and this tendency to lateral evolution in the spiral cones is carried to its extreme in the genus *ARYPA* where the multispiral cones of the fully matured forms of the Devonian, may sometimes have their axes nearly parallel. This is the termination of all revolution of the cones, a change through an arc of less than 90° , probably due in a large degree to alterations in the form of the internal cavity of the valves; and the fact that this revolution here ceases, strictly delimits the group of forms bearing spirals of this type (*ATRYPIDÆ*).

It is well to emphasize the fact, lest misconceptions already set on foot should become prevalent, that no wider revolution of the spiral cones exists. It is true that there is a difference of 180° in the position of the axes of the spiral cones in *CYCLOSPIRA* and *SPIRIFER*, but the spirals have never, by gradual changes, revolved from their inverted position in the former to their everted position in the latter. Such a process might have been possible, but had it actually occurred the forms resulting would have been totally different in structure from any now known. Instead of having the primary lamellæ and jugum on the dorsal side as in all shells with everted spirals, these parts would lie on the ventral side of the shell. It must hence be inferred that the *SPIRIFERIDÆ*, the *ATHYRIDÆ*, the *MERISTIDÆ*, and all genera with everted

brachidia are related to the *ATRYPIDÆ* only through their early ancestral forms.

The Lower Silurian faunas have furnished no evidence of species with everted spirals, and this hiatus in our knowledge forbids any satisfactory deductions as to the source or derivation of these forms. It is true in a general sense that the eversion of the spirals is accompanied by a convexity of both valves, just as the inverted spirals of the *ATRYPIDÆ* are associated with valves of notably unequal depth. Still, among the latter, *GLASSIA* possesses biconvex valves, while of the former the group composed of *CÆLOSPIRA*, *ANOPLOTHECA*, *KONINCKINA* and *AMPHICLINA* is characterized by convexo-plane or convexo-concave valves. In this group also the apices of the spirals are not directed toward the lateral commissures of the valves, but toward the lateral slopes of the pedicle-valve, such a form and direction being a necessary outcome of the contracted interior space. From present evidence it would seem probable that among the early Silurian species will be found some form whose spiral ribbon deviates outwardly from the vertical plane to the same degree as it inclines inwardly in *CYCLOSPIRA* and *PROTOZYGA*. Indeed, in *Cyclospira bisulcata* itself, the spiral sometimes lies so nearly in the vertical plane that the inward inclination of the apices is not always positive. Only some such form of the earliest faunas could have been the progenitor of the everted spirals.

In the *ATRYPIDÆ* possibilities of variation in the form of the jugum were much restricted; in the other groups of the spire bearers they were very great, and resulted in the production of a wonderful series of modifications whose relations it is not necessary to rehearse here. The extreme range of these modifications is seen in the simple termination of the jugum in *WHITFIELDELLA*, *RYNCHOSPIRA*, etc.; the bifurcate extremity in *MERISTINA*, *EUMETRIA* and *RETZIA*, these terminal branches in *KAYSERIA*, *DIPLOSPIRELLA*, etc., finally becoming coextensive with the lamellæ of the primary spirals and thus forming a second pair of spiral cones. This complication of the brachidium is effected only late in the history of the various groups producing them. *KONINCKINA* and *AMPHICLINA* are double-spiraled convexo-concave shells which are the post-palæozoic and final representatives of *ANOPLOTHECA* and *CÆLOSPIRA*. *PEXIDELLA* and *DIPLOSPIRELLA*, of the St. Cassian

beds, are double-spiraled athyroids; *KAYSERIA*, of the middle Devonian, which is the only double-spiraled form known in the Palæozoic, appears to be an aberrant and accelerated representative of the stock which by more gradual development produced *RETZIA* and *EUMETRIA*.

Only one large group of spire-bearing shells retains the cardinal area, namely, the *SPIRIFERIDÆ*, a family with everted spirals, one of the earliest to appear and the last to disappear. Its abundant representatives possess the longest of spirals and for the most part these are greatly extended transversely, held at arm's length, as it were, unsupported by a connecting jugum (except in the more sparsely represented genera *CYRTINA* and *SPIRIFERINA*), but in spite of the delicacy of the structure, its apparent mechanical disadvantages in the absence of a continuous jugum, this type of structure has maintained its distinctive character and multiplied in a most remarkable manner.

The relations of the brachiopods with spiral brachidia, to the *ANCYLOBRACHIA*, or those shells commonly spoken of as the terebratuloids, has been a fruitful subject of discussion and given rise to investigations of great astuteness and merit. Reference has already been made to the facts established by *BEECHER* and *SOHUCHERT* from the development of the brachidium in *ZYGOSPIRA*, which show that this atrypid passes through a growth stage in which the brachidium has a simple terebratuloid form, similar to that in the mature condition of *DIELASMA*; that the spirals are formed by the continued growth of the descending lamellæ of the loop beyond the point of their recurvature into the ascending lamellæ. What is thus true of *ZYGOSPIRA* we must assume to have been true of the *HELICOPEGMATA* generally, and the analogies thus established between them and the loop-bearing shells are these;—the entire loop in *DIELASMA*, *CRYPTONELLA*, etc., corresponds to that portion of the brachidium, in the spire-bearing forms, which lies behind the anterior basal edges of the jugum; the descending lamellæ of the former represent only the posterior portion of the primary lamellæ of the latter, while the ascending lamellæ and transverse connecting band of the *ANCYLOBRACHIA* are the equivalent of the jugum in the spire-bearers. The spirals, however, are a later development in the individual, and are hence undoubtedly a subsequent phyletic condition. Hence it is inferred

that the spire-bearing forms have derived their brachidia from a primitive terebratuloid condition, and this derivation has been effected by growth with accompanying resorption. The progressive modification of the loop in the recent terebratellids by resorption of calcareous tissue in the growth of the individual, is a well-known fact which has invited the study of many investigators. In such forms this modification is extreme and is unquestionably complicated by the intimate connexion of the loop with the median septum of the brachial valve. Among the palæozoic genera there is, with the single exception of *TROPIDOLEPTUS*, no clear evidence that the median septum has shared in, or contributed to the growth-modifications of the brachial supports; nevertheless, the outcome and final result of this growth with modification in the most progressed forms of *TEREBRATELLA* and such palæozoic genera as *DIELASMA*, *CRYPTONELLA*, *HARTINA*, etc., is the same.

Progressive modification of the brachial supports in both the *HELICOPEGMATA* and palæozoic *ANCYLOBRACHIA* being now fully established, it is interesting to observe that the primitive condition of the loop, as in *Dielasma turgida*, is one of simple apposition of the two short brachial processes, at their expanded anterior extremities; having the expression of the mature loop in the genera *CENTRONELLA*, *RENSSELLERIA*, *SELENELLA*, etc. A simple step further back would afford a condition in which the brachial processes with their expanded extremities are not as yet united but discrete as in the rhynchonellids. A more primitive condition than that in *CENTRONELLA* or the centronellid stage in *DIELASMA*, could not be different from this. On the ground of these differences in the conditions of the brachidium and the phyletic stages corresponding thereto, it would seem fair to infer that of the rhynchonellids, the terebratuloids and the spire-bearers, the first is the primitive stock, and the spire-bearers legitimate derivatives of that stock, through the terebratuloids, or both of the latter derived along divergent lines from the rhynchonellids. This conclusion, however coherent and consistent with the geological evidence, will be found to lack stability until the data are sufficient to establish the fact that the brachia themselves, and not alone their calcareous supports, have passed through corresponding phases of growth and

derivation. This latter question must long be a matter of legitimate speculation, and in view of this fact few arguments of such a nature in this place will be permissible. The living representatives of *RHYNCHONELLA* and *TEREBRATULA* are animals in which a very considerable part of the brachia does not become sufficiently spiculized to form a continuous calcareous support. In *R. (Hemithyris) psittacea*, for example, the brachia are as highly developed in the form of coiled spiral arms as they could have been in most of the ancient spire-bearers, but their calcareous supports are only the short lamellæ known as the crural processes. All of the living *ANCYLOBRACHIA* which possess a long recurved loop like that of *CRYPTONELLA* and *DIELASMA* of the Palæozoic, have an unsupported median unpaired spiral arm, coiled in a direction which is the reverse of that prevailing among the spire-bearers. If, now, we are to interpret the condition of the brachia in the fossil rhynchonellids and terebratuloids from the adult condition of the brachia in their nearest living representatives, it becomes necessary to assume that on the one hand the palæozoic rhynchonellids possessed long coiled spiral arms, and, on the other, that *DIELASMA* and its palæozoic allies and affines, when mature, were provided with the unpaired coiled arm of *TEREBRATULA*. This assumption, in the first place, totally destroys the inference above made as to the primitive relation of the rhynchonellids to the *ANCYLOBRACHIA* and *HELICOPEGMATA*; and secondly, would seem to necessitate a novel and unexpected interpretation of the brachial structure in all the spire-bearers. If *DIELASMA* possessed the median arm, supported at its base by the transverse band of the loop, which corresponds to the jugum or the spire-bearers, then in the *DIELASMA*-stage of *ZYGOSPIRA* and other spiriferous shells, where this stage was well defined, there must also have been a median coiled arm of some extent. This median arm, in living forms, is due, as shown by BEECHER, to the necessity of finding room for the cilia or tentacles multiplying at the extremities of the brachia. The mere presence of the transverse band in *DIELASMA* and the *DIELASMA*-stage of *ZYGOSPIRA* implies a similar extension of the brachia, and from the analogy, a median arm. The subsequent growth of the brachia in *ZYGOSPIRA*, carrying the calcareous ribbon forward, beyond the bases of the loop and into lateral spiral cones, would not of itself afford sufficient rea-

son for assuming that the growth of the brachia at their extremities, which produced the median arm, was necessarily discontinued, but rather that this median unpaired arm coexisted with the lateral paired spirals. This course of argument, though seemingly logical, appears to be based on insufficient premises. The brachiopods with which we have to deal in the Palæozoic are essentially primitive structures, whether rhynchonellids, terebratuloids or spire-bearers. If the living *RHYNCHONELLA* and *TEREBRATELLA* possess in their mature condition extensive free arms, it does not necessarily follow that their early palæozoic representatives were provided with similar uncalcified extensions; on the contrary, it would be much more reasonable and in accordance with our knowledge of natural laws to infer that in these early forms the adult condition of the brachia was more nearly that of immature conditions of these organs in their living representatives. There is a primitive condition of development in the *ANCYLOBRACHIA* in which the loop is coextensive with the brachia. There is reason to believe that such has been the relation of these parts in the primitive terebratuloids, as *CENTRONELLA*, *RENSSELÆRIA*, *CRYPTONELLA*, *DIELASMA*, etc.; in *TROPIDOLEPTUS*, which has been shown to represent a highly primitive phyletic condition of the *TEREBRATELLIDÆ*; and, also in the earliest spire-bearers and rhynchonellids. Hence the conclusion above expressed as to the successive phyletic relations of the primitive rhynchonellids, terebratuloids and spire-bearers and based upon the relations and modifications in the form of their brachial supports, is fairly substantiated by the evidence drawn from other data.

The divergence from the ancestral rhynchonellid stock was very early and the differentiation undoubtedly consisted, to a large extent in rapid acceleration of growth in the brachia, and obstruction to the coextensive development of the fleshy arms and their supports.

Finally, it is desirable to again recall the intimate similarity between *RENSSELÆRIA* and the pentameroid genus *AMPHIGENIA*; genera in which the essential distinction between the typical forms of each lies in the simple loop of the former and the long, expanded but still discrete crural processes of the latter. Attention has been directed to these similarities and differences, and it has also been pointed out that the spondylium in *Amphigenia elongata* is at times almost reproduced in specimens of *Rensselæria ovoides* where the dental lamellæ are highly developed.

TABLE OF CLASSIFICATION.

Class BRACHIPODA.

Paterina,* Beecher, 1891.

Sub-Class INARTICULATA, Huxley; LYOPOMATA, Owen.

Order Mesocaulia or Lingulacea, Waagen.

Family OBOLIDÆ, King.

Obolus, von Eichwald, 1829.	Obolella, Billings, 1861.
<i>Ungula</i> , Pander, 1830.	<i>Dicellomus</i> , Hall, 1871.
<i>Ungulites</i> , Bronn, 1848.	Elkania, Ford, 1886.
Aulonotreta, Kutorga, 1848.	<i>Billingsia</i> , Ford, 1886.
<i>Acritis</i> , Volborth, 1869.	Botsfordia, Matthew, 1893.
Schmidtia, Volborth, 1869.	Neobolus, Waagen, 1885.
Mickwitzia, Schmidt, 1888.	Monobolina, Salter, 1865.
Spondylobolus, McCoy, 1852.	

Family LINGULIDÆ, Gray.

Lingula, Bruguière, 1792.	Leptobolus, Hall, 1871.
<i>Pharetra</i> , Bolton, 1798.	Glossina, Phillips, 1848.
<i>Lingularius</i> , Duméril, 1806.	Dignomia, Hall, 1871.
Lingulella, Salter, 1866.	Barroisella, Hall, 1892.
Lingulepis, Hall, 1863.	Tomasina, Hall, 1892.

Family TRIMERELLIDÆ, Davidson and King

Lakhmina, Ehlert, 1887.	<i>Conradia</i> , Hall, 1862.
<i>Davidsonella</i> , Waagen, 1885.	<i>Obolellina</i> , Billings, 1871.
Lingulops, Hall, 1871.	Monomerella, Billings, 1871.
Lingulasma, Ulrich, 1889.	Trimerella, Billings, 1862.
Dinobolus, Hall, 1871.	Rhinobolus, Hall, 1874.

* The genus Paterina, representing, according to our present knowledge, the fundamental stock or radicle of all the Brachiopods, might be embraced by some of the primitive families, both of the Inarticulata and the Articulata. By placing it, in this arrangement, outside both of the great sub-classes, it is the purpose to express the fact that the genus belongs as much to one as to the other, and that it is actually beyond the pale of both as it has not assumed the differential characters of either.

Order DIACAULIA or DISCINACEA, Waagen.

Family DISCINIDÆ, Gray.

Discinolepis, Waagen, 1885.	<i>Lingulodiscina</i> , Whitfield, 1890.
Paterula, Barrande, 1879.	Orbiculoidea, d'Orbigny, 1847.
Schizobolus, Ulrich, 1886.	Schizotreta, Kutorga, 1848.
Trematis, Sharpe, 1847.	Lindströmella, Hall, 1892.
Schizocrania, Hall and Whitfield, 1875.	Römerella, Hall, 1892.
Øhlertella, Hall, 1892.	

Family SIPHONOTRETIDÆ, Kutorga, 1848.

Acrothele, Linnarsson, 1876.	Schizambon, Walcott, 1884.
Linnarssonina, Walcott, 1885.	Siphonotreta, de Verneuil, 1845.
Discinopsis, Matthew, 1892.	Orbicella, d'Orbigny, 1849.
Acrotreta, Kutorga, 1848.	<i>Keyserlingia</i> , Pander, 1861.
Conotreta, Walcott, 1889.	Helmersenina, Pander, 1861.
Mesotreta, Kutorga, 1848.	

Order GASTEROPEGMATA or CRANIACEA, Waagen.

Family CRANIIDÆ, King.

Crania, Retzius, 1781.	Craniella, Øhlert, 1887.
<i>Numulus</i> , Stobœus, 1732.	Cardinocrania, Waagen, 1885.
<i>Ostracites</i> , Beuth, 1776.	Ancistrocrania, Dall, 1877.
<i>Criopus</i> , Poli, 1791.	<i>Cranopsis</i> , Dall, 1871.
<i>Criopoderma</i> , Poli, 1791.	Craniscus, Dall, 1871.
<i>Orbicula</i> , Cuvier, 1798.	Pholidops, Hall, 1869.
<i>Orbicularius</i> , Duméril, 1806.	<i>Craniops</i> , Hall, 1859.
<i>Craniolites</i> , Schlotheim, 1820.	Pseudocrania, McCoy, 1851.
<i>Choniopora</i> , Schauroth, 1854.	Palæocrania, Quenstedt, 1871.

Sub-Class ARTICULATA, Huxley ; or ARTHROPOMATA, Owen.

Order Protremata,* Beecher.

Family KUTORGINIDÆ,† Schuchert.

Kutorgina, Billings, 1861.	(?) Volborthia, von Möller, 1873.
Schizopholis, Waagen, 1885.	Iphidea, Billings, 1872.

* In employing as the fundamental divisional distinction in the Articulata, the presence of the deltidium or the deltidial plates, the term Protremata covers better than any other those genera in which the primitive pedicle-covering is represented by either the deltidium, the spondylium, or both.

† Mr. Schuchert includes under this family term two genera, Kutorgina and Schizopholis, which have usually been regarded as belonging to the inarticulate sub-class. The reasons for the installation of these as the elementary family of the Articulata are given elsewhere.

Family ORTHIDÆ, Woodward.

Orthis, Dalman, 1828.	Bilobites, Linné, 1775.
<i>Orthambonites</i> , Pander, 1830.	<i>Dicellosia</i> , King, 1850.
Plectorthis, Hall, 1892.	Dalmanella, Hall, 1892.
Dinorthis, Hall, 1892.	Rhipidomella, Ehlert, 1880.
Plæsiomys, Hall, 1892.	<i>Rhipidomys</i> , Ehlert, 1887.
Herbertella, Hall, 1882.	Schizophoria, King, 1850.
Orthostrophia, Hall, 1883.	Orthotichia, Hall, 1892.
Platystrophia, King, 1850.	Enteletes, Fischer de Waldheim, 1830.
Heterorthis, Hall, 1892.	<i>Syntrielsma</i> , Meek, 1865.

Family STROPHOMENIDÆ, King.

Orthidium, Hall, 1892.	Derbya, Waagen, 1884.
Strophomena, Rafinesque (de Blainville), 1825.	Meekella, White and St. John, 1868.
Orthothetes, Fischer de Waldheim, 1830.	Streptorhynchus, King, 1850.
Hipparionyx, Vanuxem, 1842.	Triplecia, Hall, 1848.
Kayserella, Hall, 1892.	<i>Dicraniscus</i> , Meek, 1872.
	Mimulus, Barrande, 1879.
	Streptis, Davidson, 1881.

Family LEPTÆNIDÆ.

Leptæna, Dalman, 1828.	Strophonella, Hall, 1879.
<i>Leptagonia</i> , McCoy, 1844.	Amphistrophia, Hall, 1892.
Rafinesquina, Hall, 1892.	Leptella, Hall, 1892.
Stropheodonta, Hall, 1852.	Plectambonites, Pander, 1830.
Brachyprion, Shaler, 1865.	Christiania, Hall, 1892.
Douvillina, Ehlert, 1887.	Leptænisca, Beecher, 1890.
Leptostrophia, Hall, 1892.	Davidsonia, Bouchard, 1847.
Pholidostrophia, Hall, 1892.	Cadomella, Munier-Chalmas, 1887.

Family CHONETIDÆ.

Chonetes, Fischer de Waldheim, 1837.	Chonetina, Krotow, 1888.
Anoplia, Hall, 1892.	Chonostrophia, Hall, 1892.
Chonetella, Waagen, 1884.	Chonopectus, Hall, 1892.

Family PRODUCTIDÆ, Gray.

Strophalosia, King, 1844.	Productella, Hall, 1867.
<i>Orthothrix</i> , Geinitz, 1847.	Productus, Hall, 1867.
<i>Leptænalosia</i> , King, 1845.	Marginifera, Waagen, 1884.
Daviesiella, Waagen, 1884.	Proboscidella, Ehlert, 1887.
Aulosteges, von Helmersen, 1847.	Etheridgina, Ehlert, 1887.

 Family THECIDEIDÆ, Gray.

Thecidea, DeFrance, 1882.	Bactrynium, Emmrich, 1885.
Lacazella, Munier-Chalmas, 1880.	<i>Pterophloios</i> , Gumbel, 1861.
Thecidiopsis, Munier-Chalmas, 1887.	Davidsonella, Munier-Chalmas, 1880.
Thecidella, Munier-Chalmas, 1887.	Lyttonia, Waagen, 1883.
Eudesella, Munier-Chalmas, 1880.	Oldhamina, Waagen, 1883.

Family RICHTHOFENIDÆ, Waagen.

 Richthofenia, Waagen, 1883.

Family BILLINGSSELLIDÆ, Schuchert.

 Billingsella,* Hall, 1892.

Family CLITAMBONITIDÆ, N. H. Winchell and Schuchert.

Protorthis, Hall, 1892.	Hemipronites, Pander, 1830.
Polytoechia, Hall, 1892.	Orthisina, d'Orbigny, 1847.
Clitambonites, Pander, 1830.	Scenidium, Hall, 1860.
<i>Pronites</i> , Pander, 1830.	<i>Mystrophora</i> , Kayser, 1871.
<i>Gonambonites</i> , Pander, 1830.	

Family STRICKLANDINIDÆ.

Syntrophia, Hall, 1892.	Stricklandinia, Billings, 1859.
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Family CAMARELLIDÆ.

Camarella, Billings, 1859.	<i>Isorhynchus</i> , King, 1850.
Parastrophia, Hall, 1893.	Nœtlingia, Hall, 1892.
Anastrophia, Hall, 1879.	Lycophoria, Lahusen, 1885.
<i>Brachymerus</i> , Shaler, 1865.	Camarophoria, King, 1846.
(?) Brancaia, Gagel, 1890.	Camarophorella, Hall, 1893.
Porambonites, Pander, 1830.	

Family PENTAMERIDÆ.

Conchidium, Linné, 1753.	Sieberella, Ehlert, 1887.
<i>Gypidia</i> , Dalman, 1828.	Capellinia, Hall, 1893.
<i>Antirhynchonella</i> , Quenstedt, 1871.	Pentamerella, Hall, 1867.
<i>Zdimir</i> , Barrande, 1879.	Gypidula, Hall, 1867.
Pentamerus, Sowerby, 1813.	Amphigenia, Hall, 1867.
Barrandella, Hall, 1893.	

* The genus Billingsella presents, in correspondence with its early geological age, an elementary structural aspect indicating that it may have served as a point of departure for the Orthidæ and Strophomenidæ.

Order TELOTREMATA, Beecher.

Sub-Order Rostracea, Schuchert.

Family RHYNCHONELLIDÆ, Gray.

Protorhyncha, Hall, 1893.	Rhynchopora, King, 1856.
Orthorhynchula, Hall, 1893.	Rhynchoporina, Ehlert, 1887.
Rhynchotrema, Hall, 1860.	Rhynchonella, Fischer de Waldheim,
Rhynchotreta, Hall, 1879.	1809.
Stenoschisma, Conrad, 1839.	Halorella, Bittner, 1890.
Camarotoëchia, Hall, 1893.	Austriella, Bittner, 1890.
Liorhynchus, Hall, 1860.	Norella, Bittner, 1890.
Wilsenia (Quenstedt), Kayser, 1871.	Rhynchonellina, Gemellaro, 1871.
Uncinulus, Bayle, 1878.	Dimerella, Zittel, 1870.
Uncinulina, Bayle, 1878.	Cryptopora, Jeffreys, 1869.
Hypothyris (McCoy), King, 1850.	<i>Atretia</i> , Jeffreys, 1870.
Pugnax, Hall, 1893.	<i>Neatretia</i> , Ehlert, 1891.
Eatonia, Hall, 1857.	Peregrinella, Ehlert, 1887.
Cyclorhina, Hall, 1893.	Hemithyris, d'Orbigny.
Terebratuloidea, Waagen, 1883.	Acanthothyris, d'Orbigny.

Sub-Order ANCYLOBRACHIA, Gray.

Family CENTRONELLIDÆ, Waagen.

Rensselæria, Hall, 1859.	Juvavella, Bittner, 1890.
Beachia, Hall, 1893.	Nucleatula, Bittner, 1890.
Newberria, Hall, 1891.	Dinarella, Bittner, 1892.
Centronella, Billings, 1859.	Trigeria, Bayle, 1875.
Oriskania, Hall, 1893.	(?) Notothyris, Waagen, 1882.
Selenella, Hall, 1893.	Scaphiocœlia, Whitfield, 1891.
Romingerina, Hall, 1893.	

Family TEREBRATULIDÆ, Dall.

Cryptonella, Hall, 1861.	Terebratulina, d'Orbigny, 1847.
Eunella, Hall, 1893.	Agulhasia, King, 1871.
Harttina, Hall, 1893.	(?) Disculina, Deslongchamps, 1884.
Megalanteris, Suess, 1855.	Liothyris, Ehlert, 1887.
(?) Enantiosphen, Whidborne, 1893.	<i>Liothyris</i> , Douvillé, 1880.
Dielasma, King, 1859.	Eucalathis, Fischer and Ehlert, 1890.
<i>Epithyris</i> , King, 1850.	(?) Dyscolia, Fischer and Ehlert, 1890.
Cranæna, Hall, 1893.	Glossothyris, Douvillé, 1880.
Dielasmæna, Waagen, 1882.	Pygope, Link, 1830.
Hemiptychina, Waagen, 1882.	Propygope, Bittner, 1890.
Beecheria, Hall, 1893.	Zugmayeria, Waagen, 1882.
(?) Cryptacanthia, White and St. John,	Rhætina, Waagen, 1882.
1867.	Dictyothyris, Douvillé, 1880.
Terebratula, Klein, 1753.	Cœnothyris, Douvillé, 1880.
<i>Lampas</i> , Meuschen, 1787.	(?) Hynniphoria, Suess, 1858.

Family TEREBRATELLIDÆ, King.

Terebratella, d'Orbigny, 1847.	<i>Ornithella</i> , Deslongchamps, 1884.
Waltonia, Davidson, 1850.	Eudesia, King, 1850.
Terebratalia, Beecher, 1893.	<i>Flabellothyris</i> , Deslongchamps, 1884.
Laqueus, Dall, 1870.	(?) Orthotoma, Quenstedt, 1871.
Frenula, Dall, 1871.	Aulacothyris, Douvillé, 1880.
Trigonosemus, Koenig, 1825.	(?) Epicyrta, Deslongchamps, 1884.
Kingena, Davidson, 1852.	(?) Plesiothyris, Douvillé, 1880.
Lyra, Cumberland, 1816.	(?) Camerothyris, Bittner, 1890.
Terebrirostra, d'Orbigny, 1847.	(?) Orthoidea, Frirer, 1875.
Magellania, Bayle, 1880.	Dallina, Beecher, 1893.
Waldheimia, King, 1850.	Ismenia, King, 1850.
Neothyris, Douvillé, 1880.	Magasella, Dall, 1870.
Macandrevia, King, 1859.	Tropidoleptus, Hall, 1857.
Zeilleria, Bayle, 1878.	Platidia, Costa, 1852.
Fimbriothyris, Deslongchamps, 1884.	<i>Morrisia</i> , Davidson, 1852.
Antiptychina, Zittel, 1883.	
Microthyris, Deslongchamps, 1884.	

Family MAGASIDÆ, d'Orbigny.

Magas, Sowerby, 1816.	Rhychora, Dalman, 1828.
Bouchardia, Davidson, 1849.	Rhynchorina, Ehlert, 1887.
Mühlfeldtia, Bayle, 1880.	Mannia, Dewalque, 1874.
Megerlia, King, 1850.	

Family STRINGOCEPHALIDÆ, Dall.

Stringocephalus, Defrance, 1827.

Family MEGATHYRIDÆ, Ehlert.

Megathyris, d'Orbigny, 1847.	Zellania, Moore, 1854.
Argiope, Deslongchamps, 1842.	Gwynia, King, 1859.
Cistella, Gray, 1850.	

Sub-order HELICOPEGMATA or SPIRIFERACEA,
Waagen.

Family ATRYPIDÆ, Dall.

Hallina, N. H. Winchell and Schuchert, 1892.	Catazyga, Hall, 1893.
Protozyga, Hall, 1893.	Glassia, Davidson, 1882.
(?) Cyclospira, Hall, 1893.	Atrypina, Hall, 1893.
Zygospira, Hall, 1862.	(?) Clintonella, Hall, 1893.
Anazyga, Davidson, 1882.	Atrypa, Dalman, 1828.
Orthonomæa, Hall, 1858.	Karpinskia, Tschernyschew, 1885.
	Gruenewaldtia, Tschernyschew, 1885.

Family SPIRIFERINIDÆ, Davidson.

Cyrtina, Davidson, 1858.	Cyrtotheca, Bittner, 1890.
Bittnerula, gen. nov.	Spiriferina, d'Orbigny, 1847.
Thecocyrtella, Bittner, 1892.	Suessia, Deslongchamps, 1854.

Family SPIRIFERIDÆ, King.

Spirifer, Sowerby, 1815.	Martiniopsis, Waagen, 1883.
Choristites, Fischer de Waldheim, 1825.	Cyrtia, Dalman, 1828.
<i>Trigonotreta</i> , Koenig, 1825.	Syringothyris, A. Winchell, 1863.
<i>Brachythyris</i> , McCoy, 1844.	Ambocoëlia, Hall, 1860.
<i>Fusella</i> , McCoy, 1844.	Metaplasia, Hall, 1893.
Delthyris, Dalman, 1828.	Verneulia, Hall, 1893.
Reticularia, McCoy, 1844.	Mentzelia, Quenstedt, 1871.
Martinia, McCoy, 1844.	

Family NUCLEOSPIRIDÆ, Davidson.

Nucleospira, Hall, 1858.	Whitfieldella, Hall, 1893.
Dayia, Davidson, 1882.	Hyattella, Hall, 1893.
Hindella, Davidson, 1882.	(?) Camarospira, Hall, 1893.

Family CÆLOSPIRIDÆ.

Anoplothea, Sandberger, 1856.	Leptocoëlia, Hall, 1859.
<i>Bifida</i> , Davidson, 1882.	(?) Anabaia, Clarke, 1893.
Cœlospira, Hall, 1863.	

Family RETZIIDÆ.

Rhynchospira, Hall, 1859.	Retzia, King, 1850.
Homœospira, Hall, 1893.	Uncinella, Waagen, 1883.
Ptychospira, Hall, 1893.	Eumetria, Hall, 1864.
Trematospira, Hall, 1857.	Acambona, White, 1862.
Parazyga, Hall, 1893.	Hustedia, Hall, 1893.

Family UNCITIDÆ, Waagen.

Uncites, DeFrance, 1825.

Family MERISTELLIDÆ, Waagen.

Merista, Suess, 1851.	Charionella, Billings, 1861.
<i>Camarium</i> , Hall, 1859.	(?) Pentagonia, Cozzens, 1846.
Dicamara, Hall, 1893.	<i>Goniocoëlia</i> , Hall, 1861.
Meristella, Hall, 1860.	Dioristella, Bittner, 1890.

Family ATHYRIDÆ, Waagen.

Meristina, Hall, 1867.	Anomactinella, Bittner, 1890.
<i>Whitfieldia</i> , Davidson, 1882.	Amphitomella, Bittner, 1890.
Glassina, Hall, 1893.	Pomatospirella, Bittner, 1893.
Athyris, McCoy, 1844.	Tetractinella, Bittner, 1890.
<i>Spirigera</i> , d'Orbigny, 1847.	Pentactinella, Bittner, 1890.
Cliothyris, King, 1850.	Diplospirella, Bittner, 1890.
Actinoconchus, McCoy, 1844.	Euractinella, Bittner, 1890.
Seminula, McCoy, 1844.	Pexidella, Bittner, 1890.
Spirigerella, Waagen, 1883.	Anisactinella, Bittner, 1890.
Kayseria, Davidson, 1882.	

Family KONINCKINIDÆ, Davidson, 1853.

Koninckina, Suess, 1853.

Amphiclina, Laube, 1865.

Koninckella, Munier-Chalmas, 1880.

Thecospira, Zugmayer, 1880.

Amphiclinodonta, Bittner, 1890.

Koninckodonta, Bittner, 1893.

INCERTÆ SEDIS.

Eichwaldia, Billings, 1858.

Dictyonella, Hall, 1867.

Aulacorhynchus, Dittmar, 1871.

Isogramma, Meek and Worthen,
1873.

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Tetractinella, II, 35 (783).
Thecidea, II, 149 (897).
Thecidella, II, 151 (899).
Thecidiopsis, II, 151 (899).
Thecidium, II, 149 (897).
Thecocyrtella, II, 17 (765).

- | | |
|---|--|
| <p> <i>Thecospira</i>, II, 73 (821).
 <i>Tomasina</i>, I, 99 (231).
 <i>Torynifer</i>, II, 195 (943).
 <i>Trematis</i>, I, 126 (258).
 <i>Trematobolus</i>, I, 119 (251).
 <i>Trematospira</i>, II, 50 (798).
 <i>Trigeria</i>, II, 108 (856).
 <i>Trigonosemus</i>, II, 140 (888).
 <i>Trigonotreta</i>, II, 3 (751).
 <i>Trimerella</i>, I, 104 (236).
 <i>Triplecia</i>, I, 157 (289).
 <i>Tropidoleptus</i>, II, 123 (870).

 <i>Uncinella</i>, II, 46 (794).
 <i>Uncinulina</i>, II, 80 (828).
 <i>Uncinulus</i>, II, 80 (828).
 <i>Uncites</i>, II, 43 (793). </p> | <p> <i>Ungula</i>, I, 110 (242).
 <i>Ungulites</i>, I, 110 (242).

 <i>Verneuilia</i>, II, 14 (762).
 <i>Vitulina</i>, II, 56 (804).
 <i>Volborthia</i>, I, 117 (249).

 <i>Waldheimia</i>, II, 131 (879).
 <i>Waltonia</i>, II, 141 (889).
 <i>Whitfieldella</i>, II, 18 (766).
 <i>Whitfeldia</i>, II, 22 (770).
 <i>Wilsonia</i>, II, 79 (827).

 <i>Zeilleria</i>, II, 135 (883).
 <i>Zellania</i>, II, 149 (897).
 <i>Zdimir</i>, II, 94 (842).
 <i>Zugmayeria</i>, II, 130 (878).
 <i>Zygospira</i>, II, 64 (812). </p> |
|---|--|

ADDENDA.

Orthotropia, Hall, 1894.

(For illustration see Palæontology of New York, Vol. VIII, part 2, pl. 84, figs. 3-7.)

Elongate biconvex shells with short hinge, erect cardinal area, open delthyrium, deep muscular scar in the pedicle-valve forming a sessile spondylium from the anterior extremity of which extends a short median septum. There is also a median septum in the brachial valve.

Type, *Orthotropia dolomitica*, Hall. Niagara group.

Torynifer, Hall, 1894.

(For illustration see Palæontology of New York, Vol. VIII, part 2, pl. 84 figs. 34, 35.)

Shells athyroid in external aspect, but with a well-defined cardinal area and a distinct spondylium in the pedicle-valve supported by a median septum.

Type, *Torynifer criticus*, Hall. Lower Carboniferous (St. Louis group).

EXPLANATION OF PLATES.

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PLATE 23.

- Legend: D. Deltidial plates (deltarium). b. Dental sockets.
t. Teeth. x. Extension of crural plates.
d. Dental lamellæ. a. Adductors.
s. Median septum. r. Diductors.
c. Crura. j. Cardinal process.

SPIRIFER, SOWERBY.

(RADIATI.)

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SPIRIFER RADIATUS, Sowerby.

- Fig. 1. Dorsal view of a specimen retaining the deltarium and external surface.
Fig. 2. The interior of a pedicle-valve; showing the teeth and muscular impressions.
Fig. 3. A portion of the interior of the brachial valve; showing dental sockets and crural plates.
Niagara group. *Waldron, Indiana.*
Fig. 4. The interior of a portion of conjoined valves; showing a low median septum in the brachial valve.
Niagara dolomites. *Wisconsin.*

SPIRIFER EUDORA, Hall.

- Fig. 5. The exterior of the pedicle-valve; showing the lineate surface.
Fig. 6. An enlargement of the surface.
Niagara group. *Waldron, Indiana.*

SPIRIFER PLICATELLUS, Linné.

- Fig. 7. Dorsal view of a typical specimen from the upper Silurian of Sweden.

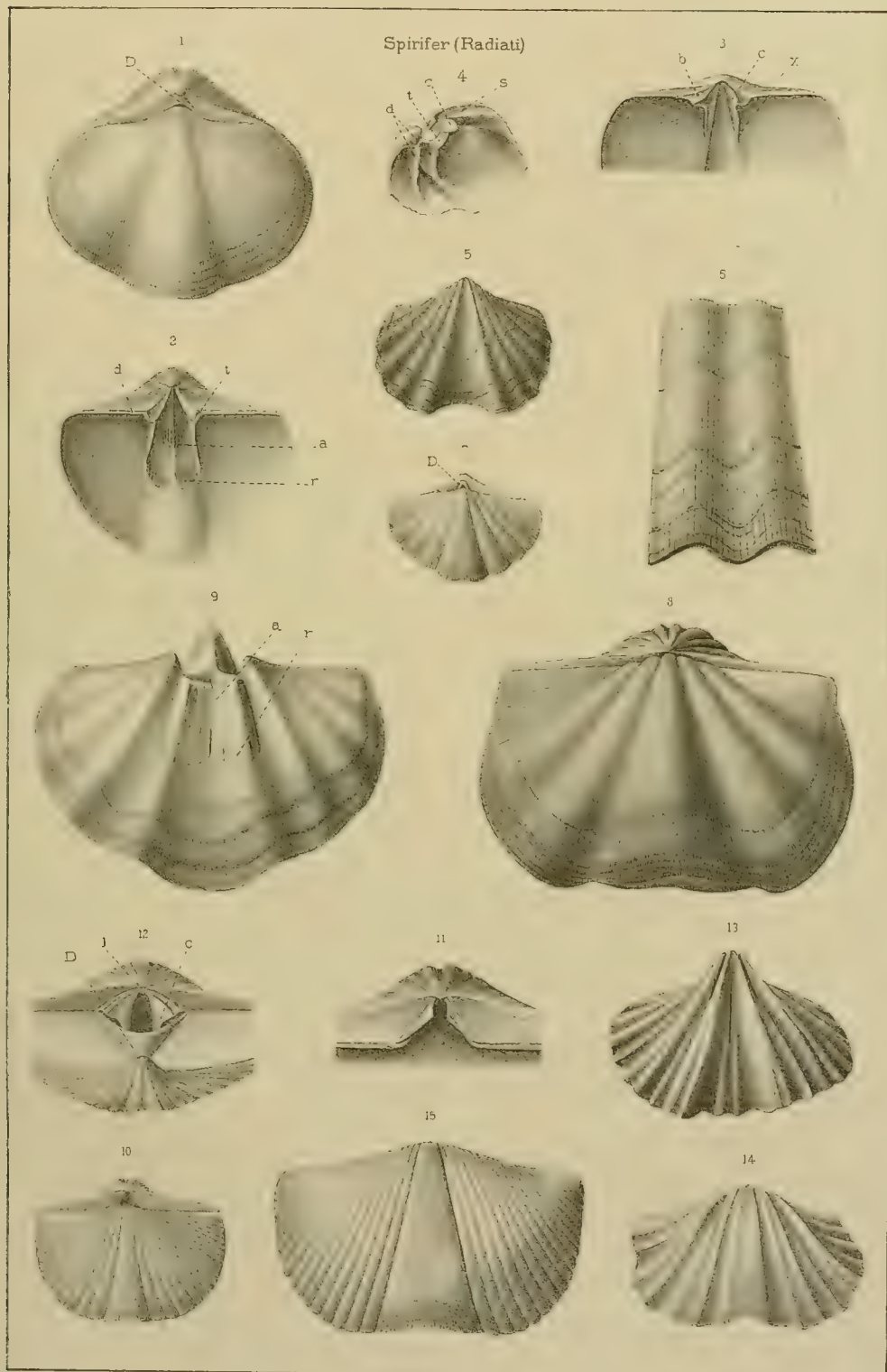
SPIRIFER MACROPLEURA, Conrad.

- Fig. 8. A dorsal view of a normal mature individual; showing the external characters.
Fig. 9. An internal cast of the pedicle-valve; showing the impressions of the pedicle-, adductor and diductor scars.
Lower Helderberg group. *The Helderbergs, N. Y.*

BRACHIOPODA. Generic Illustrations.

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Plate 23.



Philip Ast lith.

James B. Lyon, State Printer.

SPIRIFER NIAGARENSIS, Conrad.

Fig. 10. A dorsal view; showing the lineate-plicate surface.

Fig. 11. Cardinal view of a portion of the pedicle-valve; showing partially developed deltidial plates. $\times 3$.

Fig. 12. The median portion of the cardinal areas of conjoined valves; showing the deltarium cardinal process and crural plates. $\times 3$.
Niagara group. *Lockport, N. Y.*

SPIRIFER NOBILIS, Barrande.

Fig. 13. An internal cast of the pedicle-valve; showing the form of the shell.

Fig. 14. An internal cast of the brachial valve.
Niagara dolomites. *Wisconsin.*

SPIRIFER MESASTRIALIS, Hall.

Fig. 15. The exterior of a brachial valve.
Chemung group. *Southern central New York.*

PLATE 24.

- Legend : D. Deltarium. c. Crural bases.
F. Foramen. s'. Callosity in rostral cavity.
t. Teeth. j. Cardinal process.
s. Septum. a. Adductor scars.
A. Cardinal area. r. Diductor scars.
b. Dental sockets.

SPIRIFER, SOWERBY.

(LAMELLOSI.)

Page 754.

SPIRIFER MESACOSTALIS, Hall.

- Fig. 1. An internal cast of the pedicle-valve; showing the cavity of the median septum and dental plates.
Chemung group. *Southern New York.*

SPIRIFER RARICOSTUS, Conrad.

- Fig. 2. An oblique view of the pedicle-valve; showing the median septum.
Fig. 3. Dorsal view of an essentially entire individual.
Corniferous limestone. *Western New York.*

SPIRIFER SULCATUS, Hisinger.

- Fig. 4. An enlargement of the central portion of the cardinal area of the pedicle-valve; showing the discrete deltidial plates.
Fig. 5. An individual of normal proportions; showing the lamellose exterior.
Niagara group. *Lockport, N. Y.*

SPIRIFER PERLAMELLOSUM, Hall.

- Fig. 6. The interior of a pedicle-valve; showing the imperforate deltarium and the median septum.
Fig. 7. A normal adult shell, retaining the deltarium and foramen.
Lower Helderberg group. *The Helderbergs, N. Y.*

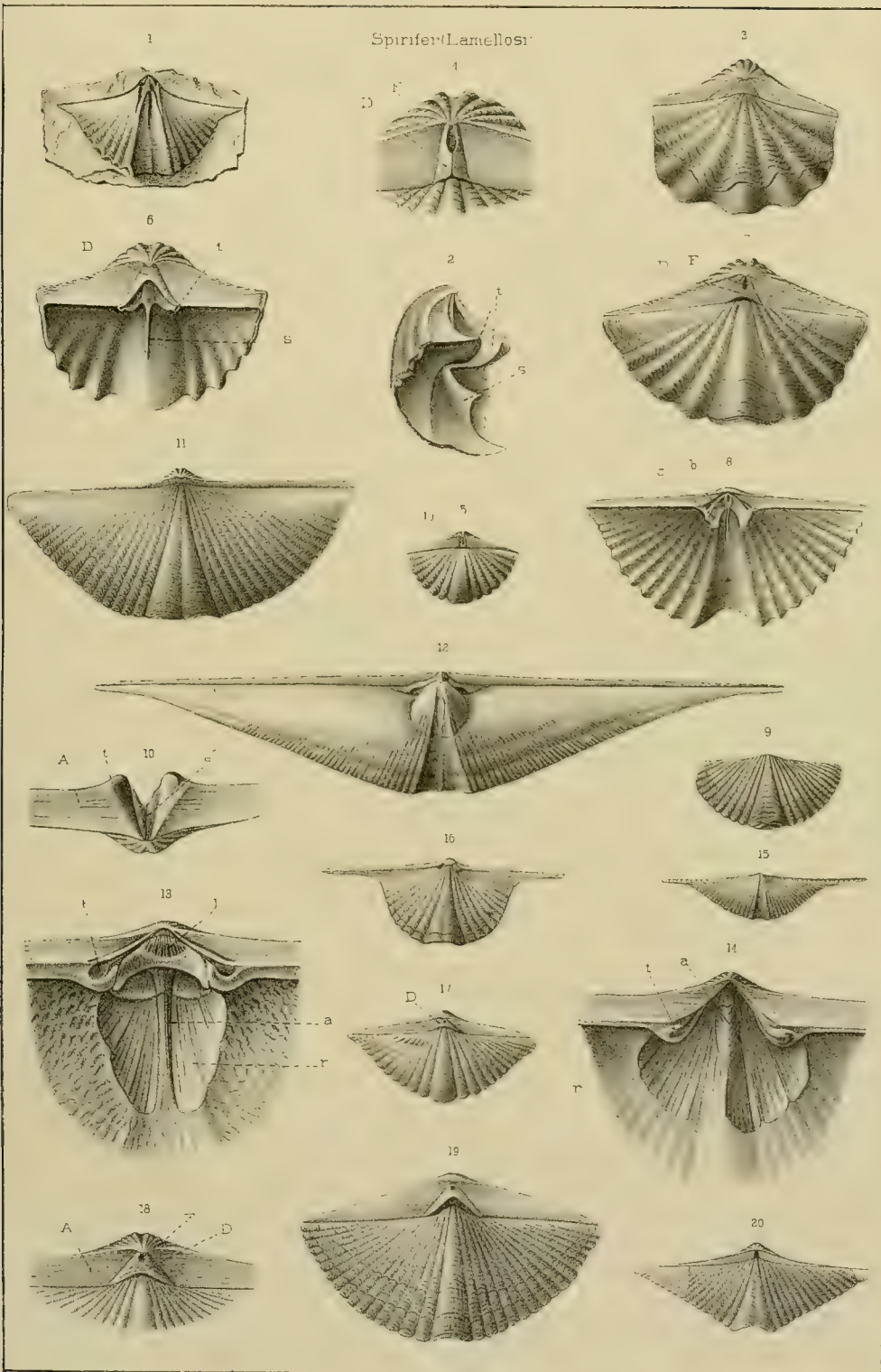
SPIRIFER VARICOSUS, Hall.

- Fig. 8. The interior of a brachial valve; showing the articulating apparatus.
× 2.
Fig. 9. A brachial valve; showing the character of the exterior.
Fig. 10. An enlarged view of the central cardinal region of the pedicle-valve.
Corniferous limestone. *Western New York.*

BRACHIOPODA. Generic Illustrations.

Report State Geologist, 1893.

Plate 24.



Philip Ast lith.

James B. Lyon, State Printer

SPIRIFER MUCRONATUS, Conrad.

- Fig. 11. A specimen of the usual form and proportions.
Hamilton group. *Canandaigua Lake, N. Y.*
- Fig. 12. An internal cast of a pedicle-valve with greatly extended and acuminate cardinal extremities.
Hamilton group. *Schoharie county, N. Y.*
- Fig. 13. An enlargement of a portion of the brachial valve; showing the cardinal process, dental sockets and muscular scars. In this figure the lettering is inaccurate; *t* should be *b*; the lines *a* and *r* are incorrect; they should be *a* and *a'* and be directed to the anterior and posterior adductor impressions respectively.
- Fig. 14. The corresponding parts of the pedicle-valve similarly enlarged.
Hamilton shales. *Western New York.*
- Fig. 15. A small pedicle-valve with highly extended cardinal extremities.
Marcellus shales. *Near Alden, N. Y.*
- Fig. 16. An individual with long, narrow, acuminate cardinal extremities.
Hamilton shales. *Darien Center, N. Y.*

SPIRIFER SUBMUCRONATUS, Hall.

- Fig. 17. The exterior of a normal example retaining the deltarium.
- Fig. 18. An enlargement of the cardinal portion of the same specimen.
Oriskany sandstone. *Cumberland, Maryland.*

SPIRIFER CUMBERLANDÆ, Hall.

- Fig. 19. An average individual retaining the deltarium and showing the lamellose surface.
Oriskany sandstone. *Cumberland, Maryland.*

SPIRIFER BIMESIALIS, Hall.

- Fig. 20. Dorsal view of a characteristic specimen.
Upper Devonian. *Independence, Iowa.*

PLATE 25.

- | | |
|--------------------------------|--------------------|
| Legend: Δ . Delthyrium. | b. Dental sockets. |
| t. Teeth. | c. Crural bases. |
| d. Dental plates. | a. Adductor scars. |
| D. Deltaria. | r. Diductor scars. |
| j. Cardinal process. | |

SPIRIFER, SOWERBY.

(FIMBRIATI).

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SPIRIFER CRISPUS, Hisinger.

- Fig. 1. Dorsal view of an entire individual. $\times 2$.
 Fig. 2. An enlargement of the cardinal portion of the brachial valve.
 Fig. 3. The interior of a pedicle-valve. $\times 2$.
 Fig. 4. An enlargement of the external surface showing concentric rows of spine bases.
 Niagara shales. *Western New York*.

SPIRIFER VANUXEMI, Hall.

- Fig. 5. Dorsal view of an entire individual; showing the external characters.
 $\times 3$.
 Lower Helderberg group. *Litchfield, N. Y.*

SPIRIFER CYCLOPTERUS, Hall.

- Fig. 6. Dorsal view of an average example.
 Lower Helderberg group. *Schoharie, N. Y.*

SPIRIFER DUODENARIUS, Hall.

- Fig. 7. Dorsal view of a normal adult.
 Corniferous limestone. *Western New York*.

SPIRIFER LÆVIS, Hall.

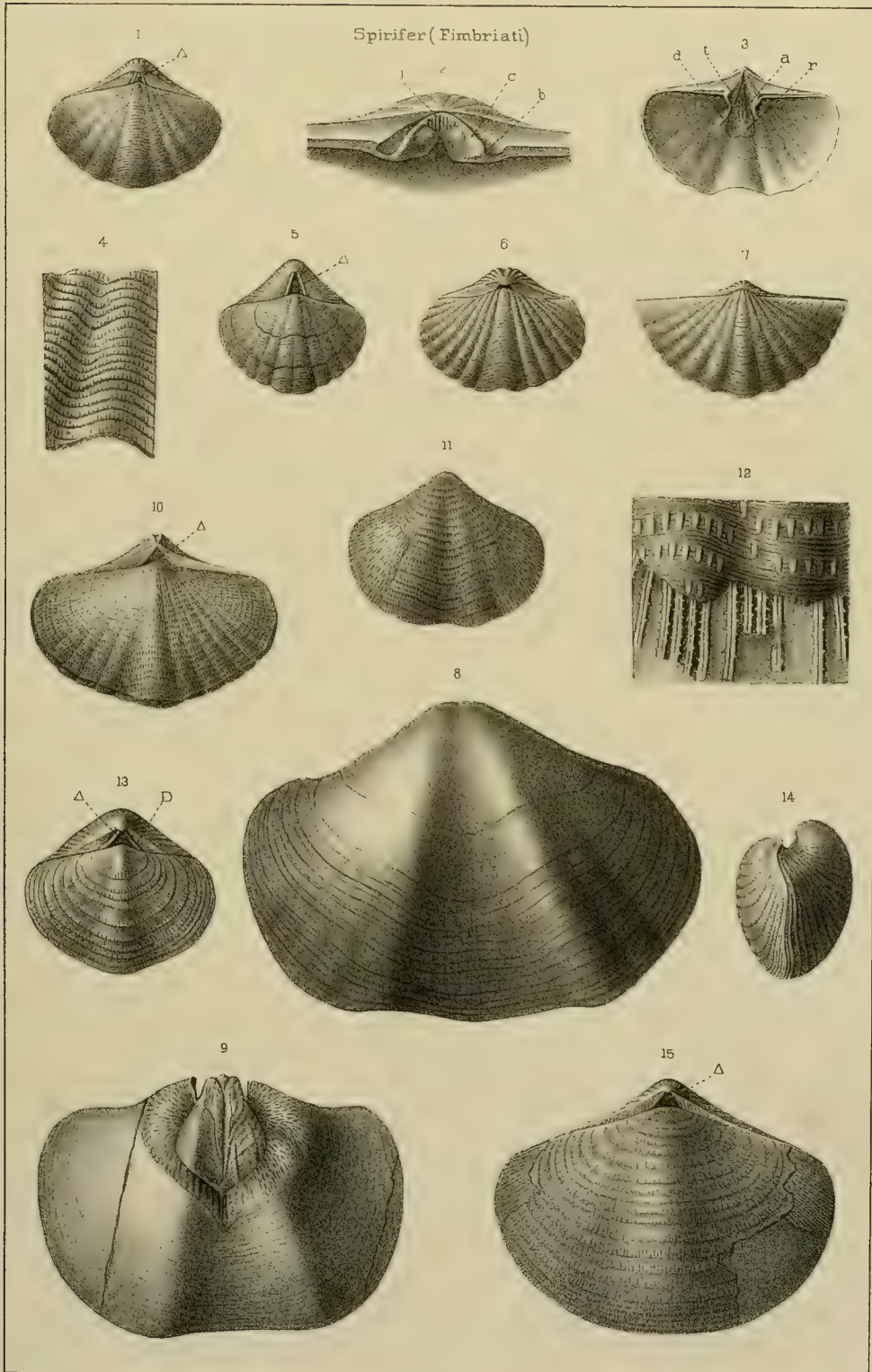
- Fig. 8. The exterior of a pedicle-valve, bearing faint lateral plications.
 Fig. 9. An internal cast of a pedicle-valve; showing the filling of the muscular impression and the ovarian markings.
 Portage group. *Ithaca, N. Y.*

BRACHIOPODA.

Generic Illustrations.

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Plate 25.



SPIRIFER FIMBRIATUS, Conrad.

Fig. 10. Dorsal view of an individual with low lateral plications.
Corniferous limestone. *Western New York.*

Fig. 11. A pedicle-valve retaining a portion of the epidermal spinules.

Fig. 12. An enlargement of a portion of the exterior; showing the double-barreled spinules and their lateral branches.
Hamilton shales. *Western New York.*

SPIRIFER SETIGERUS, Hall.

Figs. 13, 14. Dorsal and profile views of a rotund and normal individual; showing incipient deltidaria and fimbriated lamellæ.
Chester limestone. *Chester, Illinois.*

SPIRIFER PSEUDOLINEATUS, Hall.

Fig. 15. Dorsal view of a large, partially exfoliated shell; showing the concentric spine-bases.
Keokuk limestone. *Keokuk, Iowa.*

PLATE 26.

- Legend: d. Dental plates. a. Anterior adductors.
j. Cardinal process. á. Posterior adductors.
b. Dental sockets. r. Diductors.
s. Median ridge.

SPIRIFER, SOWERBY.

(APERTURATI.)

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SPIRIFER ARENOSUS, Conrad.

- Fig. 1. Dorsal view of a small but characteristic example.
Fig. 2. A preparation showing the structure of the brachial supports.
Oriskany sandstone. *Cumberland, Maryland.*

SPIRIFER WHITNEYI, Hall.

- Fig. 3. Dorsal view of a normal example.
Fig. 4. The interior of a brachial valve; showing the articulating apparatus
and muscular scars.
Upper Devonian. *Rockford, Iowa.*

SPIRIFER DISJUNCTUS, Sowerby.

- Fig. 5. An internal cast of an example with extended cardinal extremities;
showing the scar of the diductor muscle.
Chemung group. *Southern New York.*

SPIRIFER HUNGERFORDI, Hall.

- Fig. 6. Dorsal view of the exterior; showing the fine plication and obscure
median fold.
Upper Devonian. *Rockford, Iowa.*

SPIRIFER CAMERATUS, Morton.

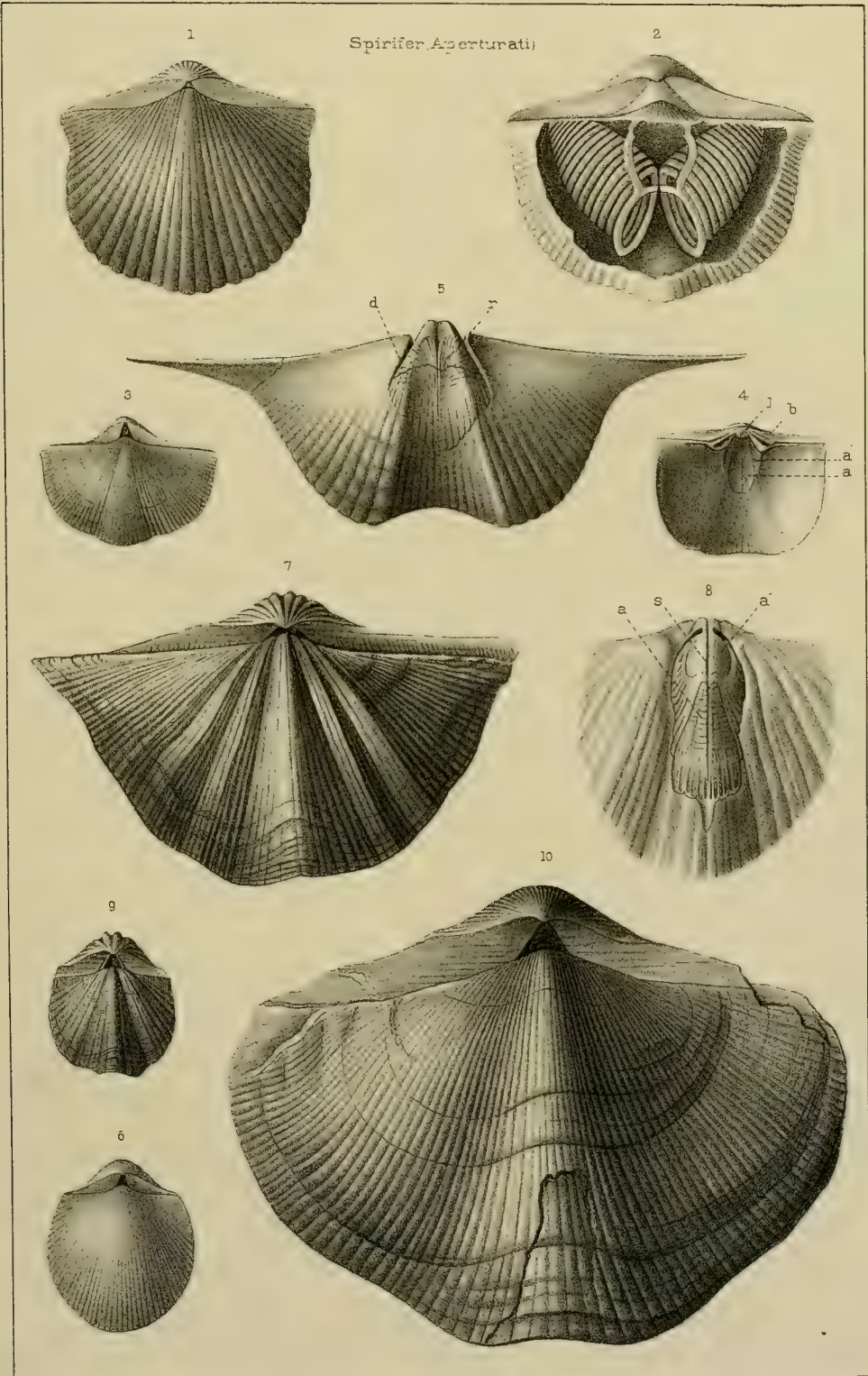
- Fig. 7. Dorsal view of a large individual; showing the usual angular fascicu-
lation of the plications.
Coal measures. *Missouri.*
Fig. 8. An enlargement of a portion of the internal cast of the brachial valve
showing the subdivision of the narrow muscular area into anterior
and posterior adductor scars.
Coal measures. *Illinois.*

BRACHIOPODA.

Generic Illustrations.

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Plate 26.



SPIRIFER TEXANUS, Meek.

Fig. 9. Dorsal view of a small example.
Coal measures. *Missouri*.

SPIRIFER LOGANI, Hall.

Fig. 10. A dorsal view of the original specimen; showing the great size and
general external characters of the species.

Keokuk limestone. *Near Nauvoo, Illinois.*

120 205

PLATE 27.

- | | |
|-------------------------|------------------------|
| Legend: D. Deltarium. | △ Delthyrium. |
| A. Cardinal area. | Dg. Deltidial grooves. |
| a'. Its inner division. | s'. Rostral callous. |
| a". Its outer division. | Adt. Denticulations. |
| t. Teeth. | r. Diductors. |

SPIRIFER, HALL.

(APERTURATI.)

Page 756.

SPIRIFER IMBEX, Hall.

- Fig. 1. The exterior of a brachial valve.
Burlington limestone. *Burlington, Iowa.*

SPIRIFER SUBEQUALIS, Hall.

- Fig. 2. Dorsal view of the original specimen.
Warsaw limestone. *Warsaw, Illinois.*

SPIRIFER MARIONENSIS, Shumard.

- Fig. 3. Dorsal view of a rather small example; showing the fasciculate plications.
Choteau limestone. *Pike county, Missouri.*

SPIRIFER CONCINNUS, Hall.

- Fig. 4. Dorsal view of a large individual; showing the incipient plications on the fold.
Fig. 5. Cardinal area of the pedicle-valve retaining the deltarium.
Lower Helderberg group. *The Helderbergs, N. Y.*

SPIRIFER GRIERI, Hall.

- Fig. 6. Dorsal view of a normal example.
Upper Helderberg group. *Ohio.*

SPIRIFER ORESTES, Hall and Whitfield.

- Fig. 7. A normal adult individual.
Chemung group. *Rockford, Iowa.*

SPIRIFER INCREBESCENS, Hall.

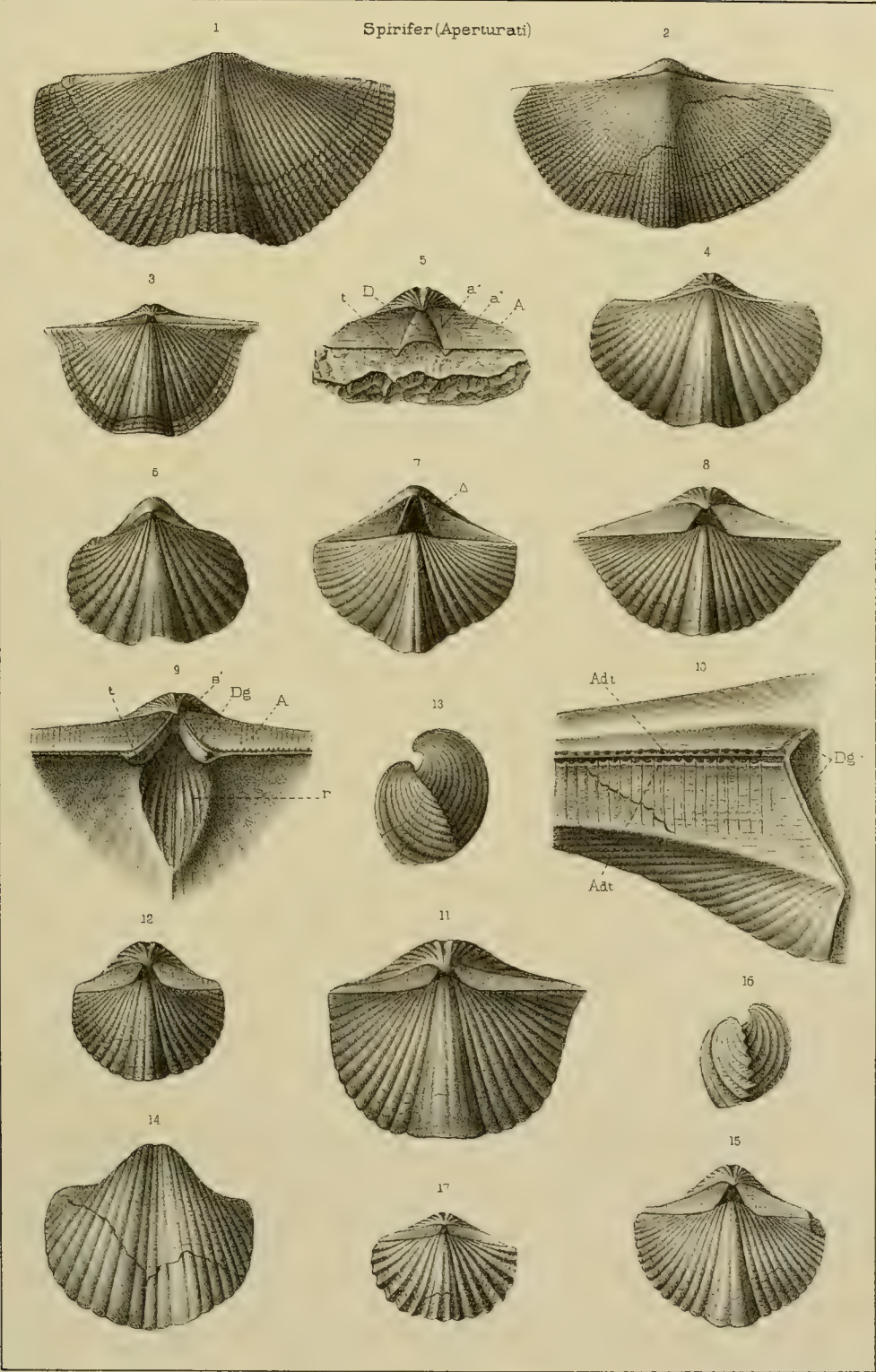
- Fig. 8. A rather small example with extended hinge-line.
Fig. 9. A portion of the interior pedicle-valve; showing the denticulations along the hinge-line, the delthyrial callous and the form of the muscular scar; enlarged.

BRACHIOPODA.

Generic Illustrations.

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Plate 27.



Philip Ast lith.

James B. Lyon, State Printer

Fig. 10. An enlargement of the cardinal area to show the denticulated cardinal edge of the pedicle-valve. The surface of the shell on the area is somewhat exfoliated, exposing the series of vertical canals, each of which terminates in a denticle. The margin of the brachial valve shows a series of small sockets corresponding to the denticles.

Fig. 11. Dorsal view of a large specimen with rather short hinge.
Chester limestone. *Chester, Illinois.*

SPIRIFER OPIMUS, Hall.

Figs. 12, 13. Dorsal and profile views of a normal individual.
Coal measures. *Iowa.*

SPIRIFER KEOKUK, Hall.

Fig. 14. Ventral view of a normal example.

Fig. 15. Dorsal view of a similar specimen.
Keokuk group. *Keokuk, Iowa.*

SPIRIFER LEIDYI, Norwood and Pratten.

Figs. 16, 17. Profile and dorsal views of a normal individual.
Chester limestone. *Chester, Illinois.*

PLATE 28.

Legend: Δ . Delthyrium.	C. Dental sockets.
t. Teeth.	c'. Crural bases.
S'. Apical callosity.	r. Diductor scars.
D. Deltarium.	a. Anterior adductors.
D. Delthyrial groove.	a'. Posterior adductors.
F. Delthyrium.	a., a." (Pedicule-valve) anterior and
d. Dental plates.	posterior divisions of the
j. Cardinal process.	cardinal area.

SPIRIFER, SOWERBY.

(OSTIOLATI.)

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SPIRIFER AUDACULUS, Conrad.

- Fig. 1. The interior of a pedicle-valve; showing the muscular area and delthyrial callous.
- Figs. 2, 3. Dorsal and profile views of the exterior.
- Fig. 4. The interior of a brachial valve; showing the articulating apparatus and adductor scars.
- Fig. 5. The median portion of the cardinal area of the pedicle-valve, enlarged; showing the external form and extent of the delthyrial callous.
- Fig. 6. A similar portion of the pedicle-valve, enlarged to show the apical callous and the lower part of the deltarium.
- Fig. 7. An enlargement of a portion of the interior of the brachial valve; showing the adductor impressions and the articulating apparatus.
Hamilton shales. *Western New York.*

SPIRIFER MACRONOTUS, Hall.

- Fig. 8. A cardinal view of a large example retaining the deltarium.
Hamilton shales. *Western New York.*

SPIRIFER ASPER, Hall.

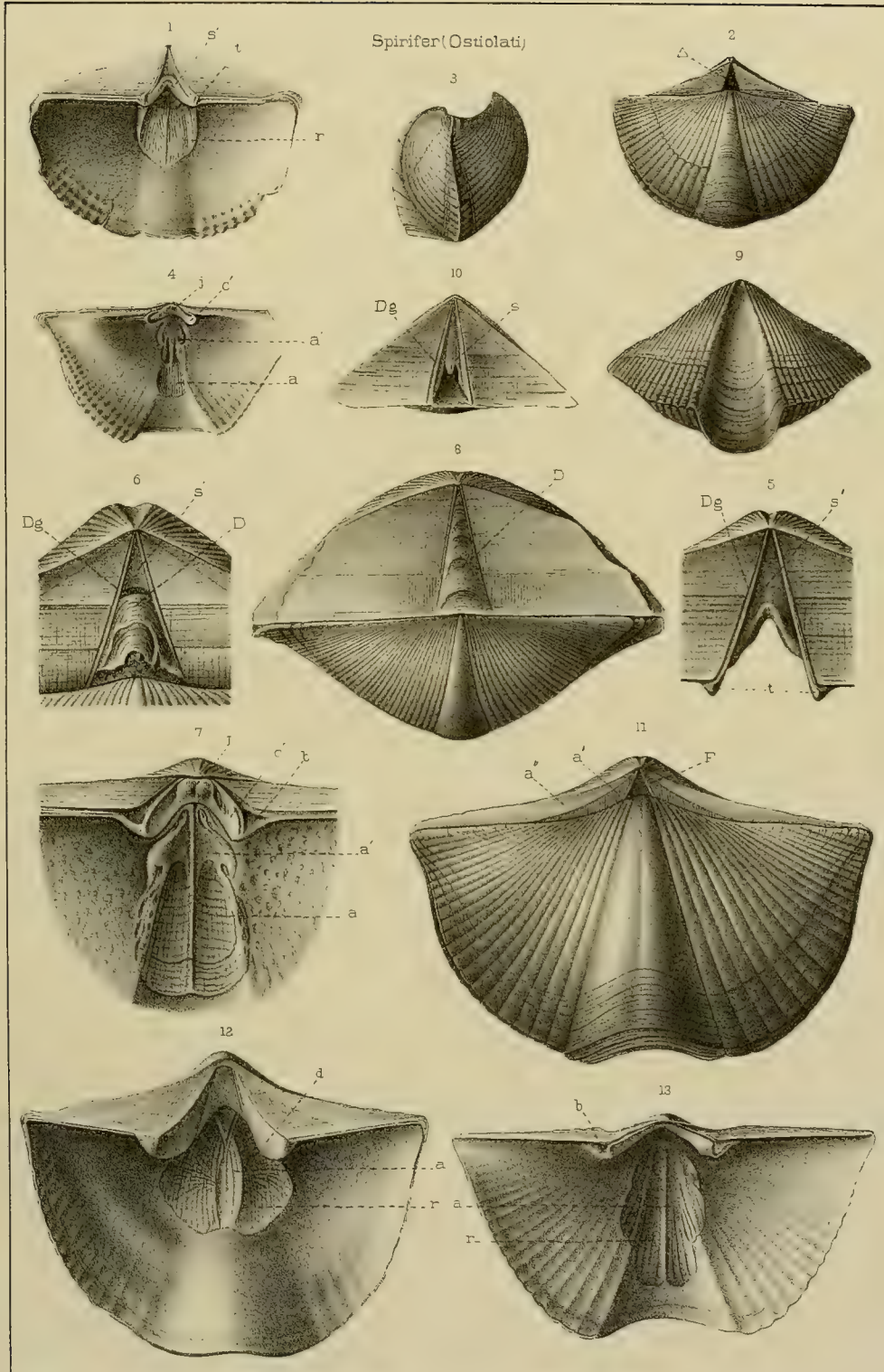
- Fig. 9. Front view of a normal individual.
Hamilton group. *New Buffalo, Iowa.*
- Fig. 10. Cardinal view of a pedicle-valve with highly developed delthyrial callosity.
Hamilton group. *Rockford, Iowa.*

BRACHIOPODA.

Generic Illustrations.

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Plate 28.



Philip Ast lith.

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SPIRIFER GRANULOSUS, Conrad.

Fig. 11. Dorsal view of a normal adult.

Fig. 12. The interior of a pedicle-valve; showing the muscular area and delthyrial callosity.

Fig. 13. The interior of a brachial valve; showing the adductor scars and dental sockets.

Hamilton group. *Western New York.*

PLATE 29.

- | | |
|---|--|
| <p>Legend. D. Deltarium.
 F. Foramen.
 s'. Rostral callous.
 d. Dental lamellæ.
 Δ. Delthyrium.
 A. Cardinal area.
 s. Median septum.</p> | <p>(s')T. Syringoid tube.
 j. Cardinal process.
 c. Crura.
 b. Dental sockets.
 a. Adductor scars.
 r. Diductor scars.</p> |
|---|--|

SPIRIFER, SOWERBY.

(GLABRATI.)

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SPIRIFER MAIA, Billings.

- Fig. 1. Dorsal view of an exfoliated shell.
 Fig. 2. Another individual with more pronounced median fold; showing the smooth exterior.
 Corniferous limestone. *Ohio*.

SPIRIFER SUBUMBONA, Hall.

- Fig. 3. Ventral view of a preparation; showing the smooth exterior and the form of the spiral. $\times 3$.
 Limestone of the Marcellus epoch. *Stafford, N. Y.*

CYRTIA, DALMAN.

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CYRTIA EXPORRECTA, Wahlenberg.

- Fig. 4. The exterior of a normal example. (DAVIDSON.)
 Fig. 5. Transverse section of the umbonal region of the pedicle-valve; showing the dental lamellæ resting on the bottom of the valve and the thickening at their union with the deltarium.
 Wenlock limestone. *England*.

CYRTIA EXPORRECTA, Wahlenberg, var. ARRECTA, Hall and Whitfield.

- Figs. 6, 7. Cardinal and profile views of the original specimen.
 Niagara group. *Louisville, Kentucky*.

CYRTIA RADIAN, Hall.

- Figs. 8, 9. Cardinal and front views; showing the finely lineate exterior.
 Clinton group. *Rochester, N. Y.*

CYRTIA ALTA, Hall.

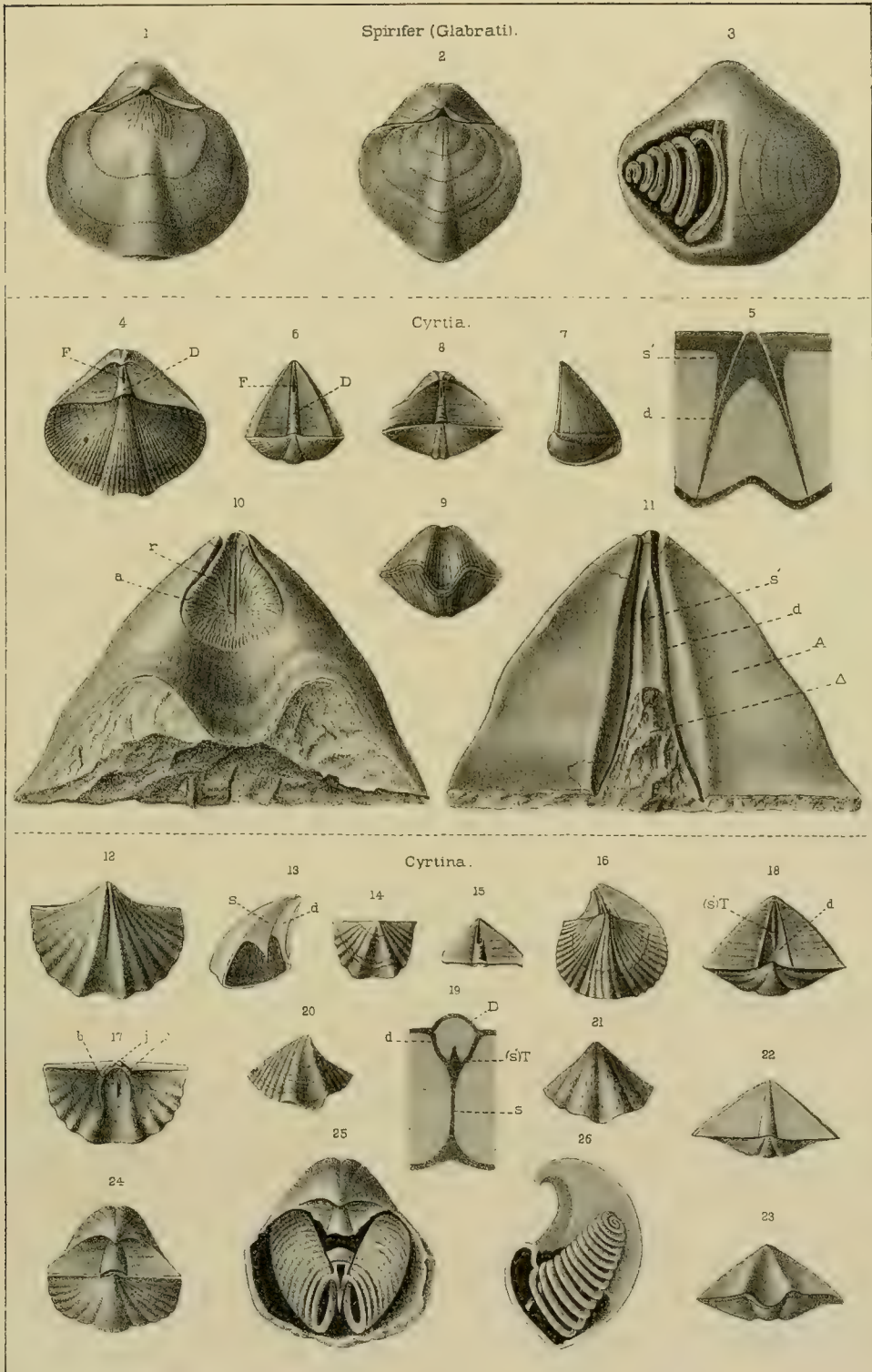
- Fig. 10. A front view of an internal cast of the pedicle-valve; showing the muscular area and the faintly plicated sinus.
 Fig. 11. A cardinal view of a similar internal cast; showing the depression left by the internal thickening of the deltarium.
 Chemung group. *Meadville, Pennsylvania*.

BRACHIOPODA.

Generic Illustrations.

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Plate 29.



Philip Ast lith.

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CYRTINA, DAVIDSON.

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CYRTINA HAMILTONENSIS, Hall.

- Fig. 12. An internal cast of the pedicle-valve; showing the position of the median septum.
Fig. 13. An axial section of combined valves; showing the form of the median septum and the supported dental plate.
Fig. 17. The interior of a brachial valve; showing the articulating processes.
Fig. 19. A portion of a transverse section of the umbonal region of the pedicle-valve; showing the deltarium and the dental lamellæ thickened at their union with the median septum, the edge of the latter extending into the deltidial cavity. $\times 3$.
Hamilton group. *Localities in Western New York.*

CYRTINA HAMILTONENSIS, var. RECTA, Hall.

- Figs. 14, 15. Views of a normal example; showing the high, erect cardinal area.
Hamilton group. *Western New York.*

CYRTINA CURVILINEATA, White.

- Fig. 16. Dorsal view of a large specimen; showing the plicated median fold of the brachial valve and the distorted umbo of the pedicle-valve.
Hamilton group. *Iowa City, Iowa.*

CYRTINA ACUTIROSTRIS, Shumard.

- Fig. 18. Cardinal view of a normal example.
Choteau limestone. *Pike county, Missouri.*

CYRTINA TRIQUETRA, Hall.

- Fig. 20. Ventral view of an average example; showing the curvature of the umbo.
Hamilton group. *Rock Island, Illinois.*

CYRTINA LACHRYMOSA, Hall.

- Fig. 21. Ventral view of an average example; showing the pustulose surface.
Waverly group. *Richfield, Ohio.*

CYRTINA BIPPLICATA, Hall.

- Figs. 22, 23. Cardinal and front views; showing the imperforate deltarium and smooth exterior.
Schoharie grit. *Schoharie, N. Y.*

CYRTINA UMBONATA, var. ALPENENSIS, Hall.

- Fig. 24. Cardinal view of a normal mature individual.
Figs. 25, 26. Dorsal and lateral views of a preparation; showing the form of the spiral cones and jugum, and the extent of the median septum. $\times 1\frac{1}{2}$.
Hamilton group. *Alpena, Michigan.*

PLATE 30.

- | | |
|-----------------------|----------------------|
| Legend: D. Deltarium. | Δ. Delthyrium. |
| T. Syrinx. | j. Cardinal process. |
| s'. Rostral callous. | a. Adductor scars. |
| d. Dental lamellæ. | r. Diductor scars. |

SYRINGOTHYRIS, A. WINCHELL.

Page 760.

SYRINGOTHYRIS TYPA, A. Winchell.

- Fig. 1. The interior of the apical portion of a pedicle-valve; showing the dental plates and syrinx.
- Fig. 2. The interior of another pedicle-valve; showing the greatly thickened syrinx inclosed along its posterior surface.
Burlington limestone. *Burlington, Iowa.*

SYRINGOTHYRIS SUBCUSPIDATA, Hall.

- Fig. 3. The interior of a large pedicle-valve; showing the rostral callous, the extension of the syrinx and the muscular scars.
Keokuk group. *Nauvoo, Illinois.*

SYRINGOTHYRIS TEXTA, Hall.

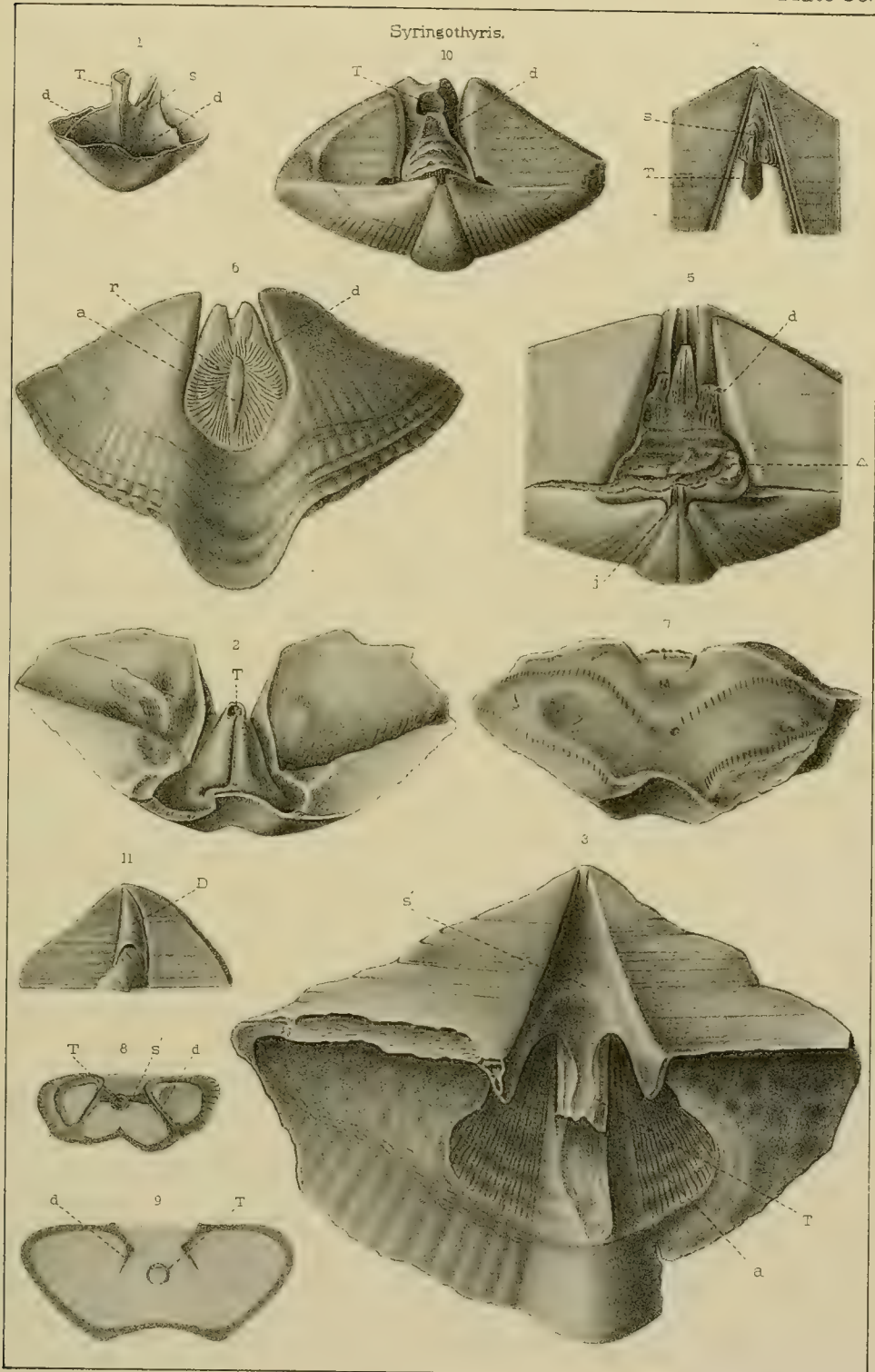
- Fig. 4. The central cardinal portion of the pedicle-valve; showing the transverse rostral plate, and the free, completed extremity of the syrinx, which is elsewhere adherent to the inner surface of the plate. $\times 2$.
- Fig. 5. The central cardinal portion of an internal cast of conjoined valves; showing impressions of the cardinal process, dental plates and the filling of the tubular portion of the syrinx.
- Fig. 6. Ventral view of an internal cast; showing the muscular scars of the pedicle-valve.
- Fig. 7. A transverse section, showing the form and extent of the spiral cones.
- Fig. 8. A transverse section of the pedicle-valve a short distance below the apex; showing the dental plates resting on the bottom of the valve, the transverse plate and the adherent syrinx.

BRACHIOPODA.

Generic Illustrations.

Report State Geologist, 1893.

Plate 30.



Philip Ast lith.

James B. Lyon, State Printer

Fig. 9. A section of the same valve nearer the hinge and below the edge of the transverse plate. The free portion of the syrinx is seen to be open on the inner side.

Keokuk group. *New Providence, Indiana.*

SYRINGOTHYRIS RANDALLI, Simpson.

Fig. 10. A cardinal view of an internal cast; showing the impression of the deltarium and the cavity left by the syrinx.

Fig. 11. Cardinal view of a pedicle-valve retaining the convex deltarium.

Waverly group. *Warren, Pennsylvania.*

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PLATE 31.

- Legend : D. Deltarium. j. Cardinal process.
 t. Teeth. b. Dental sockets.
 s, s'. Median septum. c. Crural bases.
 x. Hinge plate.

SPIRIFERINA, D'ORBIGNY.

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SPIRIFERINA TRANSVERSA, McChesney.

- Fig. 1. Dorsal view of an entire specimen ; showing the general proportions and the lamellose exterior.
 Chester limestone. *Buzzard's Roost, Alabama.*
 Fig. 3. Oblique view of the interior of a pedicle-valve ; showing the median septum.
 Carboniferous limestone. *Itaituba, Brazil.*

SPIRIFERINA SUBELLIPTICA, McChesney.

- Fig. 2. The interior of a portion of the brachial valve ; showing the articulating apparatus, elevated muscular ridges and low median septum.
 × 2.
 Keokuk group. *New Providence, Indiana.*

SPIRIFERINA SPINOSA, Norwood and Pratten.

- Fig. 4. A median longitudinal section through conjoined valves ; showing the elevation and extent of the median septum.
 Figs. 5, 6. Dorsal and ventral views of a normal example.
 Fig. 7. An enlargement of the external surface ; showing the bases of spinules and the punctæ of the shell.
 Chester limestone. *Chester, Illinois.*

AMBOCÆLIA, HALL.

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AMBOCÆLIA UMBONATA, Conrad.

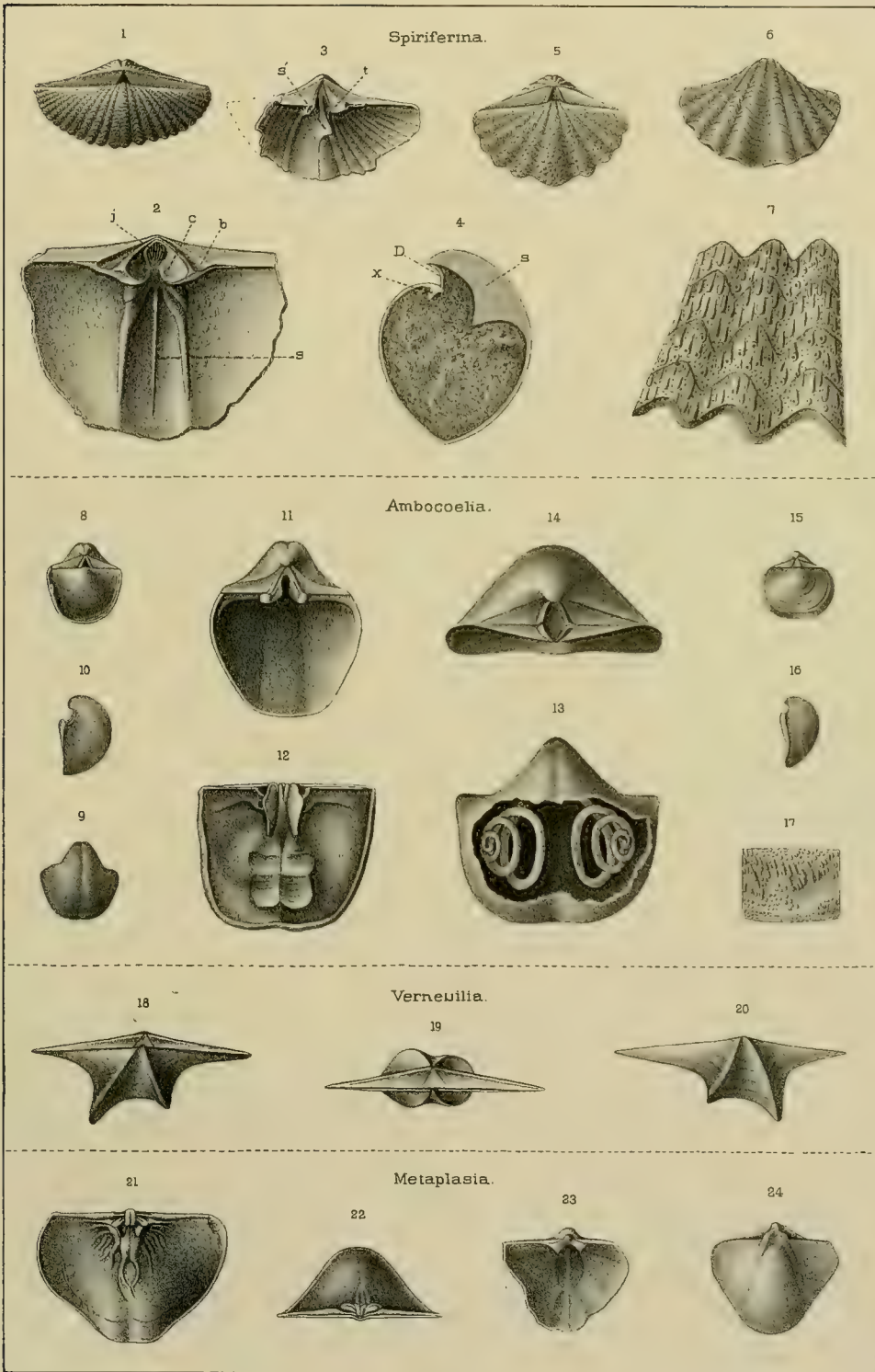
- Figs. 8, 9, 10. Dorsal, ventral and profile views of a normal shell. × 2.
 Fig. 11. The interior of a pedicle-valve, enlarged.
 Fig. 12. The interior of a brachial valve, showing the low cardinal process, high crural plates and conspicuous adductor scars.
 Fig. 13. A preparation showing the form of the spiral cones.
 Hamilton group. *Western New York.*

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AMBOCÆLIA PLANOCONVEXA, Shumard.

Fig. 14. Cardinal view of the specimen represented in Fig. 15, showing the cardinal areas, the incomplete deltaria and the chilidium. $\times 3$.

Figs. 15, 16. Dorsal and profile views of an average specimen.

Fig. 17. An enlargement of the surface, showing the short spinules.
Coal measures. *Illinois and Kansas*.

VERNEUILIA, HALL.

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VERNEUILIA CHIROPTYX, de Verneuil.

Figs. 18, 19, 20. Dorsal, cardinal and ventral views; showing the slight asymmetry of the shell and the bicinctate division of the surface.
(DE VERNEUIL.)

Middle Devonian. *Paffrath, Germany*.

METAPLASIA, HALL.

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METAPLASIA PYXIDATA, Hall.

Fig. 21. The interior of a brachial valve; showing the articulating apparatus, adductor scars and vascular sinuses about the muscular area and over the marginal regions. $\times 2$.

Fig. 22. A cardinal view of the same valve; showing the linguat extension of the median sinus on the anterior margin.

Fig. 23. The interior of a portion of a pedicle-valve; showing the narrow cardinal area, thickened teeth and deep muscular scar.

Fig. 24. An internal cast of the pedicle-valve; showing the impressions of divergent, probably vascular sinuses extending forward from the pedicle-cavity.

Oriskany sandstone. *Cayuga, Ontario*.

PLATE 32.

Legend: dl. Dental lamellæ. a. Anterior adductors.
 vs. Pedicle-cavity. a'. Posterior adductors.
 hp. Hinge-plate. r. Diductors.
 v. Vascular sinuses.

WHITFIELDDELLA, HALL.

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WHITFIELDDELLA NITIDA, Hall.

- Fig. 1. The cardinal portion of the pedicle valve; showing the teeth and the foramen almost inclosed by the substance of the valve. $\times 3$.
Figs. 2, 3. Dorsal and profile views of a large example.
Fig. 4. The cardinal portion of the brachial valve; showing the medially divided hinge-plate. $\times 3$.
 Niagara group. *Waldron, Indiana*.
Fig. 5. An internal cast of conjoined valves; showing the position of the dental plates in the pedicle-valve, the impression of the divided hinge-plate, muscular scars and vascular sinuses on the brachial valve. $\times 2$.
 Niagara dolomites. *Milwaukee, Wisconsin*.

WHITFIELDDELLA NAVIFORMIS, Hall.

- Fig. 6. The cardinal portion of a brachial valve; showing the structure of the hinge-plate, which was originally divided medially, the median cleft being partially filled by an erect lobe. $\times 3$.
 Clinton group. *Western New York*.

WHITFIELDDELLA INTERMEDIA, Hall.

- Fig. 7. Cardinal portion of the brachial valve; showing the median division of the hinge-plate. $\times 4$.
 Clinton group. *Hamilton, Ontario*.

WHITFIELDDELLA CYLINDRICA, Hall.

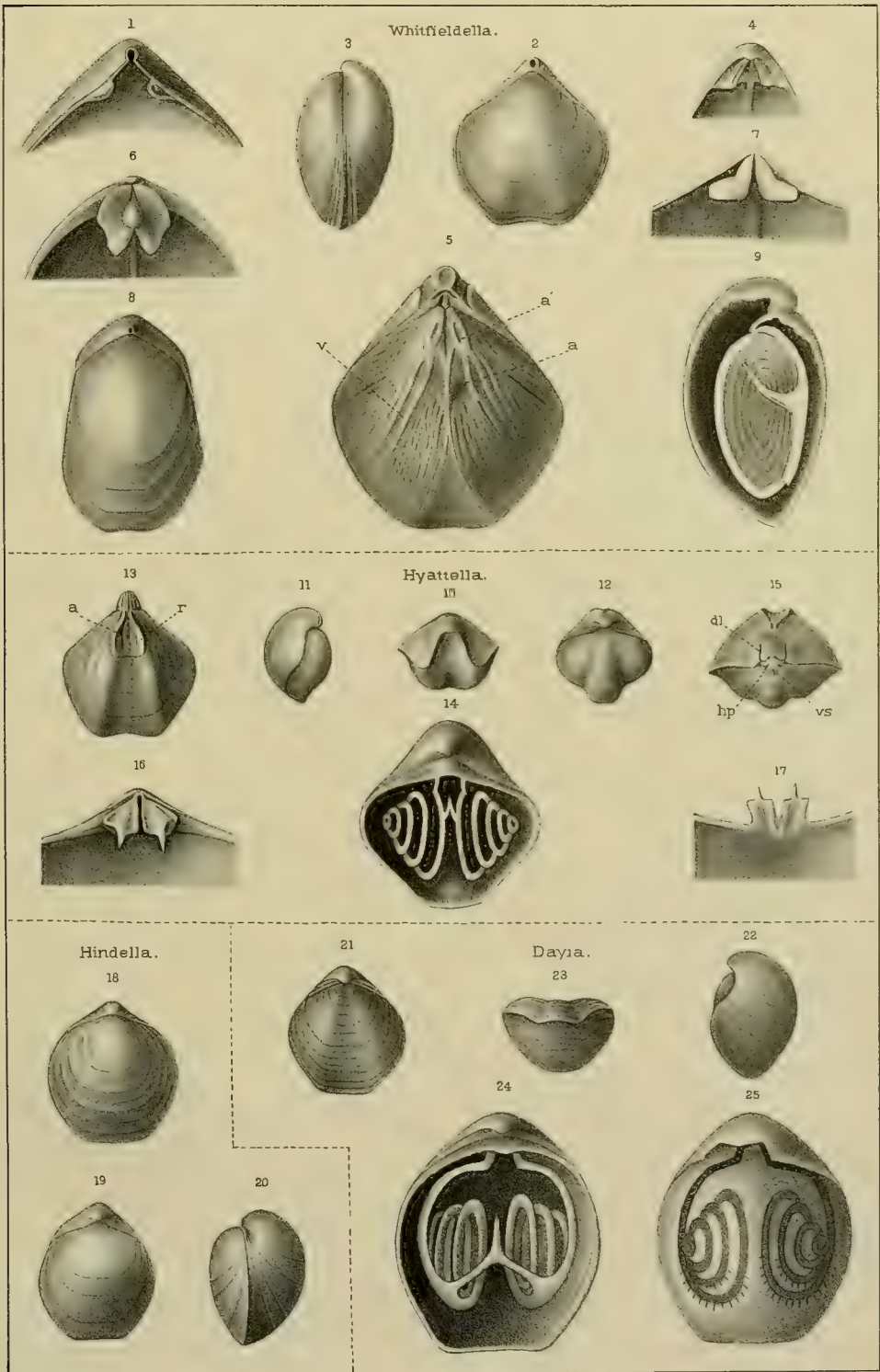
- Fig. 8. Dorsal view of a large example.
Fig. 9. A preparation showing the mode of attachment of the spirals and the form of the jugum.
 Niagara group. *Hillsboro, Ohio*.

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Plate 32.



Philip Ast lith.

James B Lyon, State Printer.

HYATTELLA, HALL.

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HYATTELLA CONGESTA, Conrad.

- Figs. 10, 11, 12. Front, profile and dorsal views of an average example, enlarged.
- Fig. 13. An internal cast of the pedicle-valve; showing the impression of the pedicle-cavity and muscular area. $\times 2$.
- Fig. 14. A preparation showing the form of the brachidium.
- Fig. 15. A cardinal view of an internal cast.
- Fig. 16. The interior of a portion of the brachial valve; showing the narrow median division of the hinge-plate. $\times 5$.
- Fig. 17. The same specimen viewed in profile from in front; showing the elevation of the lateral divisions. $\times 5$.

HINDELLA, DAVIDSON.

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HINDELLA PRINSTANA, Billings.

- Fig. 18. Dorsal view of a somewhat elongated shell.

HINDELLA UMBONATA, Billings.

- Figs. 19, 20. Dorsal and profile views of an average example.
Middle Silurian. *Junction Cliff, Anticosti.*

DAYIA, DAVIDSON.

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DAYIA NAVICULA, Sowerby.

- Figs. 21, 22, 23. Dorsal, profile and front views of the exterior, enlarged.
- Figs. 24, 25. Preparations showing the structure of the brachidium. (DMSOAGVI.)
Ludlow shales. *Shropshire, England.*

PLATE 33.

- Legend: pl. Shoe-lifter process. dl. Dental plates.
s. Septum (pedicle-valve). d. Spondylium.
s'. Septum (brachial valve).

MERISTINA, HALL.

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MERISTINA MARIA, Hall.

- Figs. 1, 2. Dorsal and profile views of an average adult.
Fig. 3. The cardinal portion of a mature pedicle-valve; showing the open delthyrium and the thickened teeth supported by dental plates. $\times 2$.
Fig. 4. The cardinal portion of the brachial valve; showing the median cleft in the hinge-plate, forming an elongate cavity supported by a median septum. $\times 2$.
Niagara group. *Waldron, Indiana*.
Fig. 5. An internal cast of a pedicle-valve; showing the impression of the muscular area and vascular sinuses.
Niagara dolomites. *Bridgeport, Illinois*.
Fig. 6. A preparation showing the structure of the brachidium.
Fig. 7. Lateral view of one of the spiral cones in its normal relations to the valves.
Niagara group. *Waldron, Indiana*.

MERISTA, SUESS.

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MERISTA TENNESSEENSIS, Hall.

- Fig. 8. Dorsal view of a broad individual.
Fig. 9. Ventral view showing the cavity left by the removal of the "shoe-lifter" process.
Fig. 10. The interior of a brachial valve; showing the divided hinge-plate and median septum.
Fig. 11. The interior of a pedicle-valve.
Lower Helderberg group. *Perry county, Tennessee*.

MERISTA TYPA, Hall.

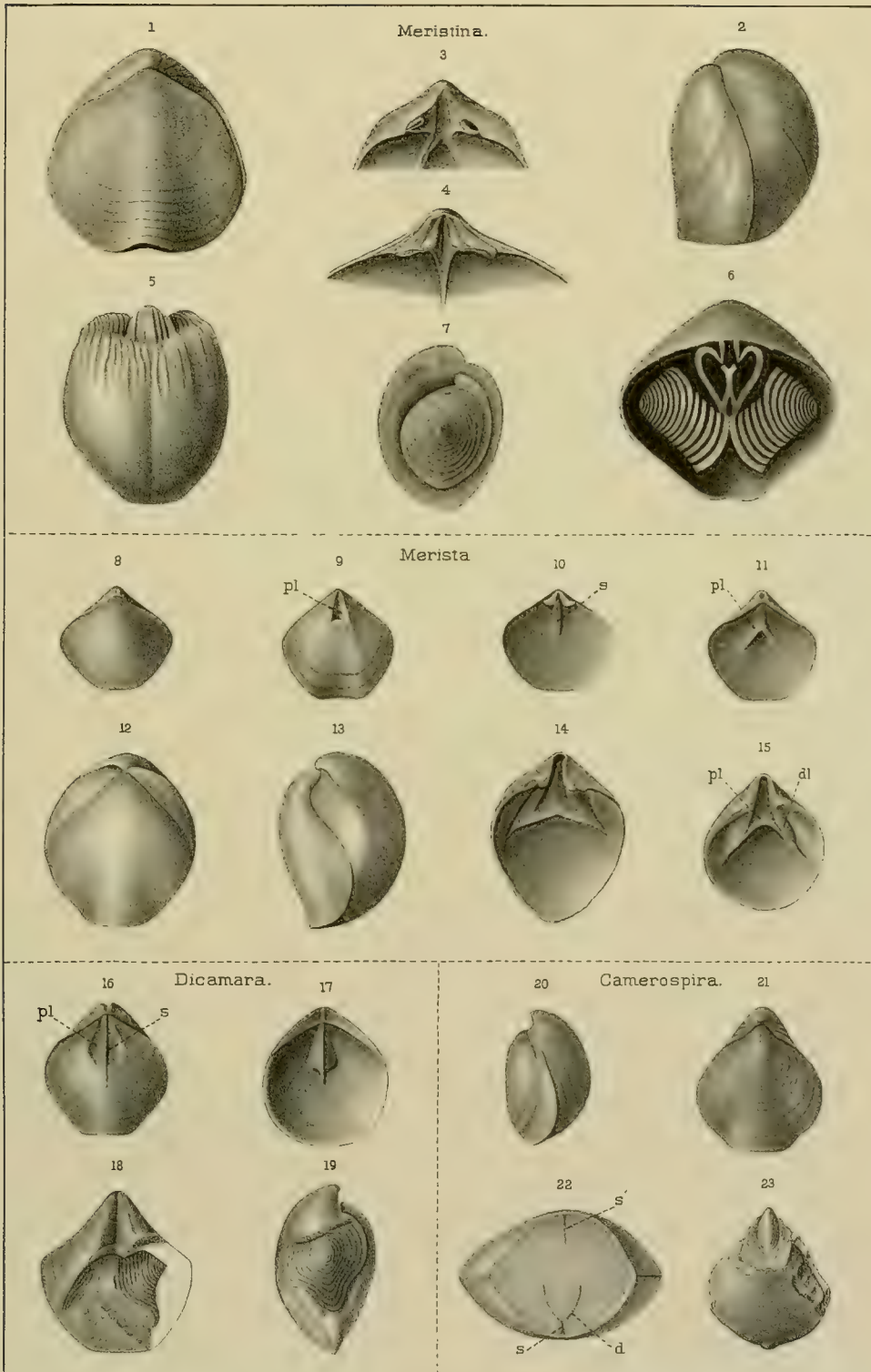
- Figs. 12, 13. Dorsal and profile views of a normal adult.
Fig. 14. The interior of a pedicle-valve; showing the great width of the "shoe-lifter" and the extension of the dental plates upon its surface.

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- Fig. 15. Interior of a pedicle-valve in which the "shoe-lifter" is highly arched and the dental plates conspicuously thickened.
Lower Helderberg group. *Cumberland, Maryland.*

DICAMARA, HALL.

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DICAMARA SCALPEUM, F. Roemer.

- Fig. 16. Dorsal view of a specimen showing the cavities left by the removal of the "shoe-lifter" of the two valves, and the median septum of the brachial valve.
Fig. 17. The interior of the brachial valve; from a gutta-percha impression.
Middle Devonian. *Pelm, Germany.*
Fig. 18. Ventral view of a specimen, showing the cavity of the "shoe-lifter" and the form of the spiral cones.
Fig. 19. Profile of the same specimen.
Upper Devonian. *Hartz Mountains, Germany.*

CAMAROSPIRA, HALL.

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CAMAROSPIRA EUCHARIS, Hall.

- Figs. 20, 21. Profile and dorsal views of a normal example.
Corniferous limestone. *Cayuga, Ontario.*
Fig. 22. A transverse section of the umbonal region; showing the spondylium and septa.
Corniferous limestone. *Cass county, Indiana.*
Fig. 23. A ventral view of a specimen so broken as to expose the spondylium.
Corniferous limestone. *Cayuga, Ontario.*

PLATE 34.

Legend: hp. Hinge-plate.
c. Crura.
t. Teeth.

b. Dental sockets.
s. Median septum.
a. Adductor scars.
r. Diductor scars.

MERISTELLA, HALL.

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MERISTELLA LEVIS, Hall.

Figs. 1, 2. Dorsal and profile views of an average example.

Fig. 3. A portion of the brachial valve, showing the subquadrate outline of the hinge-plate. $\times 3$.

Lower Helderberg group. *Albany county, N. Y.*

MERISTELLA BELLA, Hall.

Fig. 4. The interior of a pedicle-valve; showing the teeth, the deeply excavated muscular scar and the testaceous thickening which fills the pedicle-cavity except along the median line.

Fig. 5. The hinge-plate viewed in profile from in front. $\times 3$.

Lower Helderberg group. *Schoharie, N. Y.*

MERISTELLA LENTA, Hall.

Fig. 6. A longitudinal internal view, showing the position and form of the jugum.

Oriskany sandstone. *De Cewville, Ontario.*

MERISTELLA NASUTA, Hall.

Fig. 7. The interior of a brachial valve; showing the hinge-plate and muscular impressions.

Figs. 8, 9. Dorsal and profile views of a large, strongly nasute example.

Schoharie grit. *Albany county, N. Y.*

MERISTELLA WALCOTTI, Hall.

Fig. 10. A view of the brachidium from the ventral side, a portion of the cones being omitted to show the jugum.

Fig. 11. The brachidium viewed from the anterior margin; showing the normal form of the cones and jugum.

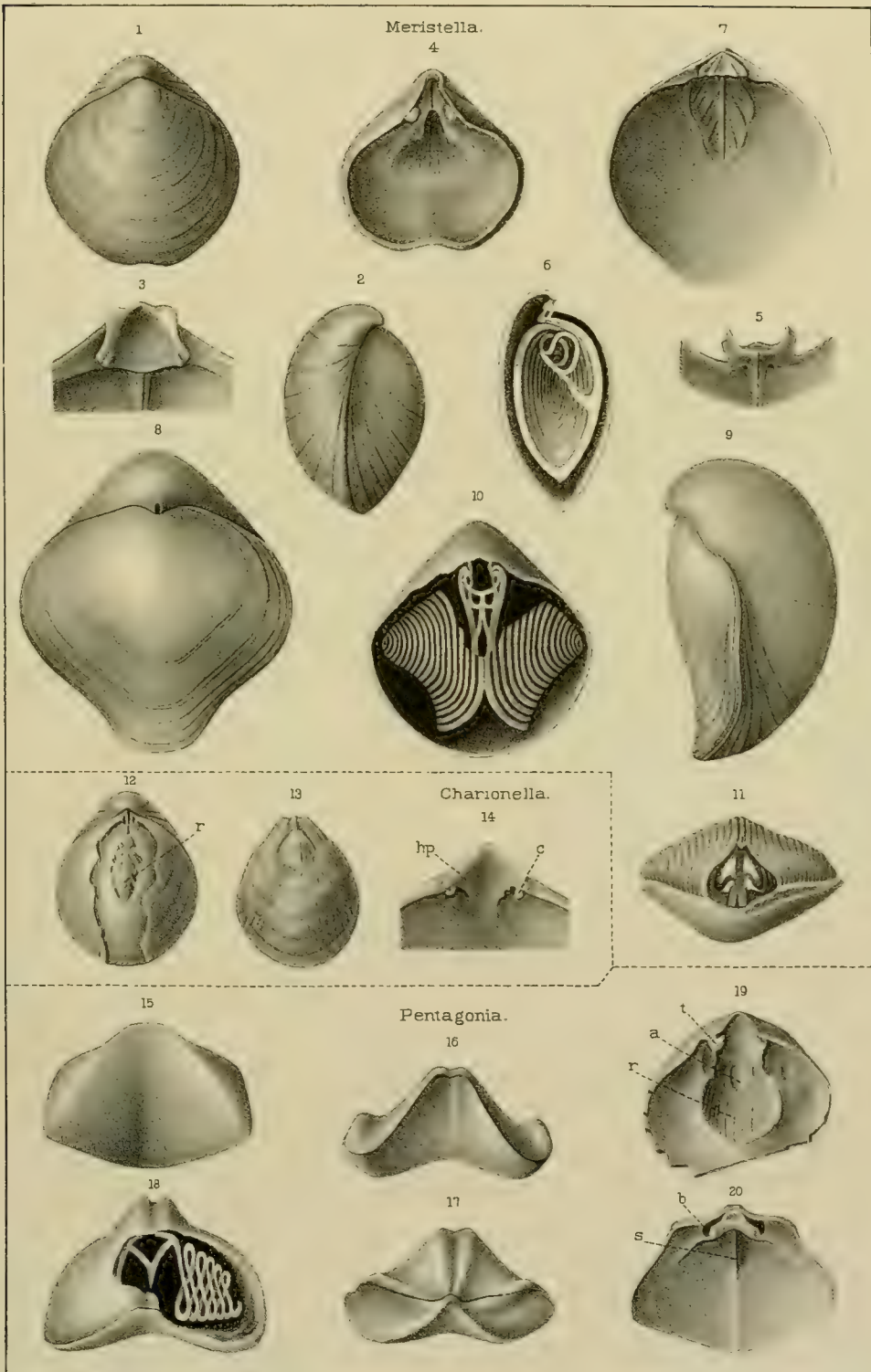
Oriskany sandstone. *Cayuga, Ontario.*

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Plate 34



CHARIONELLA, BILLINGS.

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CHARIONELLA SCITULA, Billings.

- Fig. 12. Dorsal view of a specimen from which a portion of the shell has been removed exposing the muscular impressions of the brachial valve.
Fig. 13. An internal cast of the pedicle-valve.
Fig. 14. The cardinal portion of the brachial valve; showing the concave and adherent hinge-plate. $\times 3$.
Corniferous limestone. *Cayuga, Ontario*.

PENTAGONIA, COZZENS.

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PENTAGONIA UNISULCATA, Conrad.

- Figs. 15, 16, 17. Ventral, front and cardinal views of a normal example; showing the contour of the valves.
Fig. 18. A preparation showing the form of one of the spiral cones and a portion of the jugum.
Corniferous limestone. *Western New York*.
Fig. 19. The interior of a pedicle-valve; showing the articulating apparatus and muscular scars.
Fig. 20. The interior of a brachial valve; showing the articulating processes and short, low median septum.
Corniferous limestone. *Falls of the Ohio*.

PLATE 35.

Legend: p. Pedicle cavity. a'. Posterior adductors.
a. Anterior adductors.

ATHYRIS, McCoy.

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ATHYRIS VITTATA, Hall.

- Fig. 1. Dorsal view of a normal individual.
Fig. 2. The hinge-plate; showing its trilobate form and the visceral foramen.
Fig. 3. The interior of the cardinal region of conjoined valves, the brachial valve being above. This view shows the elevation of the anterior face of the hinge-plate, the internal opening of the visceral foramen, the extension of the median lobe of the plate, the attachment of the crura to the crural lobes and their mode of union with the primary lamellæ, a portion of which is shown. $\times 3$.
Hamilton group. *Falls of the Ohio*.

ATHYRIS SPIRIFEROIDES, Eaton.

- Fig. 4. The interior of a brachial valve.
Hamilton group. *Falls of the Ohio*.
Fig. 5. The interior of a pedicle-valve; showing the adductor and diductor scars.
Hamilton group. *Western New York*.
Fig. 6. A preparation of the brachidium, one of the spiral cones having been removed to show the structure of the jugum. $\times 2$.
Hamilton group. *Alpena, Michigan*.
Fig. 7. Dorsal view of a large and old shell having the surface lamellæ highly developed.
Fig. 8. An internal cast of the pedicle-valve; showing the muscular scars and vascular impressions.
Hamilton group. *Western New York*.

CLIOTHYRIS, King.

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CLIOTHYRIS ROYSII, Lèveillé.

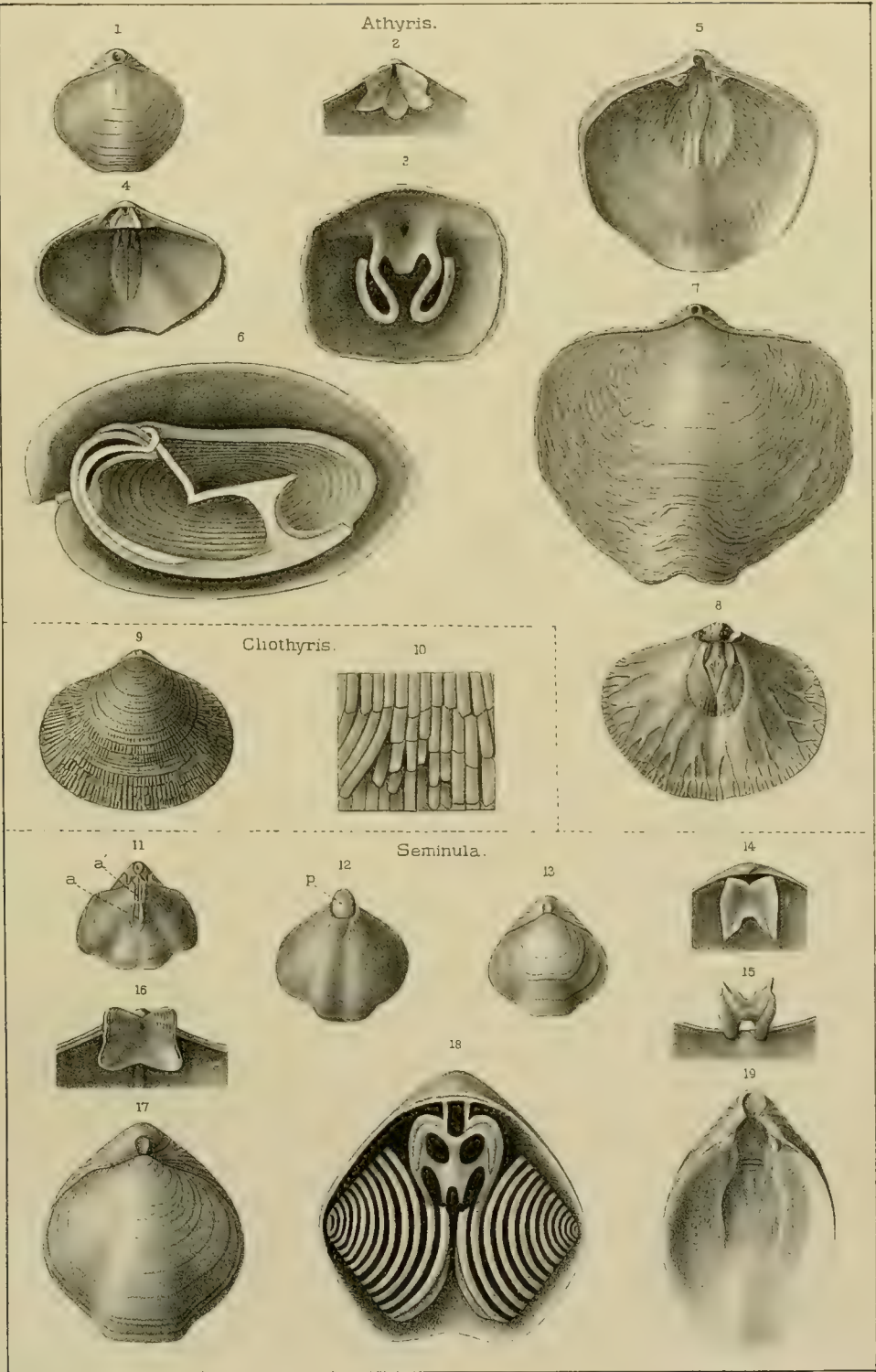
- Fig. 9. Dorsal view of an average specimen; showing the concentric rows of flat spines.
Keokuk group. *Keokuk, Iowa*.
Fig. 10. An enlargement of a portion of the surface.
Chester limestone. *Jackson county, Kentucky*.

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SEMINULA, McCoy.

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SEMINULA TRINUCLEA, Hall.

- Fig. 11. Dorsal view of a strongly trilobed internal cast; showing the character of the muscular area.
St. Louis group. *Harrison county, Indiana.*
- Fig. 12. Ventral view of an internal cast.
St. Louis group. *Spergen Hill, Indiana.*
- Fig. 14. A view of the hinge-plate; showing its subquadrate outline and the prolongation of the crural lobes. $\times 3$.

SEMINULA SUBQUADRATA, Hall.

- Fig. 13. A dorsal view of conjoined valves.
Chester limestone. *Crittenden county, Kentucky.*
- Fig. 15. An anterior view of the hinge-plate; showing the visceral foramen and the elevation of the crural lobes. $\times 3$.
St. Louis limestone. *Pella, Iowa.*

SEMINULA SUBTILITA, Hall.

- Fig. 16. A view of the hinge-plate; showing its form, concave upper face and the visceral foramen. $\times 3$.
- Fig. 17. Dorsal view of a large individual with normal proportions.
Coal measures. *Chariton county, Missouri.*
- Fig. 18. A preparation showing the structure of the brachidium. $\times 3$.
Coal measures. *Winterset, Iowa.*
- Fig. 19. The interior of an elongate and thickened pedicle-valve; showing the deep excavation of the muscular scars.
Coal measures. *Near Kansas City, Missouri.*

PLATE 36.

Legend: t. Teeth.

hp. Hinge-plate.

s. Median septum.

c. Crura.

b. Dental sockets.

KAYSERIA, DAVIDSON.

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KAYSERIA LENS, Phillips.

Figs. 1, 2. Dorsal and profile views of an average example. $\times 2$.

Middle Devonian. *Eifel, Germany.*

RETZIA, KING.

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RETZIA ADRIENI, de Verneuil.

Figs. 3, 4. Ventral and dorsal views of the exterior.

Fig. 5. Ventral view of a shell from which a portion of the brachial valve has been exfoliated; showing the median septum and a portion of one spiral.

Fig. 6. An enlarged view of a shell which has been transversely sectioned in the umbonal region; showing the hinge-plate, dental sockets and median septum.

Fig. 7. Dorsal view of the umbonal region of conjoined valves; showing the broad cardinal slopes of the pedicle-valve and the coalesced deltarium. $\times 2$.

Lower Devonian. *Department de la Sarthe, France.*

(Figs. 5, 6, CEHLERT.)

RHYNCHOSPIRA, HALL.

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RHYNCHOSPIRA FORMOSA, Hall.

Fig. 8. A dorsal view of a typical specimen.

Fig. 9. The interior of the cardinal portion of a pedicle-valve; showing the circular foramen and the completely coalesced deltarium. $\times 2$.

Fig. 10. The interior of a pedicle-valve.

Fig. 11. The interior of a brachial valve; showing the form of the hinge-plate.

Fig. 12. An interior view of the cardinal portion of articulated valves; showing the elevation of the hinge-plate and the median septum of the brachial valve. $\times 2$.

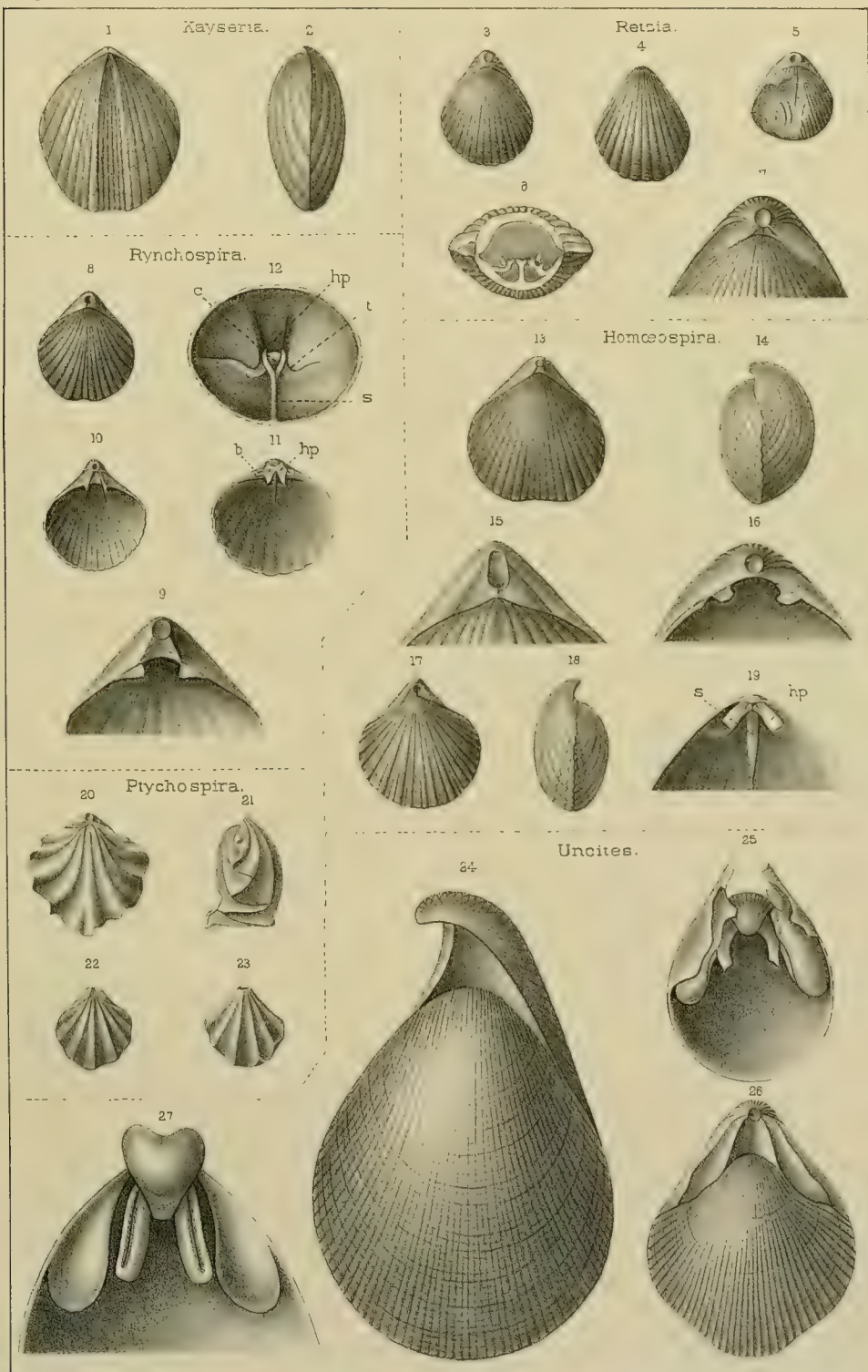
Lower Helderberg group. *The Helderbergs, N. Y.*

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HOMŒOSPIRA, HALL.

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HOMŒOSPIRA EVAX, Hall.

Figs. 13, 14. Dorsal and profile views of an adult shell.

Fig. 15. The umbonal region of a young shell in which the deltaria have united at the base, inclosing an oval foramen. $\times 7$.

Fig. 16. Similar view of a fully-matured shell; showing the complete obsolescence of the deltaria and the inclosure of the foramen by the substance of the shell. $\times 2$.

Niagara group. *Waldron, Indiana.*

HOMŒOSPIRA APRINIFORMIS, Hall.

Figs. 17, 18. Dorsal and profile views of the original example. $\times 2$.

Niagara group. *Tennessee.*

HOMŒOSPIRA cf. EVAX, Hall.

Fig. 19. The cardinal portion of the brachial valve; showing the hinge-plate and median septum. $\times 3$.

Upper Silurian. *Perry county, Tennessee.*

PTYCHOSPIRA, HALL.

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PTYCHOSPIRA FERITA, von Buch.

Figs. 20, 21. Dorsal and profile views of an average specimen. $\times 2$.

Middle Devonian. *Eifel, Germany.*

PTYCHOSPIRA SEXPLICATA, White and Whitfield.

Figs. 22, 23. Dorsal and ventral views of the original specimen. $\times 2$.

Kinderhook group. *Illinois.*

UNCITES, DEFRANCE.

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UNCITES GRYPHUS, Schlotheim.

Fig. 24. A dorsal view of a large individual with distorted, unciform beak. (F. RÖMER.)

Middle Devonian. *Eifel, Germany.*

Fig. 25. A specimen from which a portion of the pedicle-valve has been broken, exposing the interior of the brachial valve and showing the lateral pouch-shaped expansions, the incurved beak and the crura. (DAVIDSON.)

Fig. 26. Dorsal view of a specimen of medium size. (DAVIDSON.)

Middle Devonian. *Chimay, Belgium.*

Fig. 27. The interior of the umbonal region of a brachial valve, enlarged; showing the hinge-plate, lateral pouches and grooved ridges extending forward from the hinge-plate. (DAVIDSON.)

Middle Devonian. *Torquay, England.*

PLATE 37.

Legend: f. Foramen.

c. Crura.

cr. Crural plates.

tc. Posterior horns of hinge-plate.

hp. Hinge-plate.

dp. Deltarium.

p'. Anterior horn of hinge-plate.

EUMETRIA, HALL.

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EUMETRIA VERNEUILIANA, Hall.

Fig. 1. Dorsal view of an orbicular, finely lineate example.

Fig. 2. The interior of the cardinal region of articulated valves, viewed with the plane of the hinge horizontal. This preparation shows in the background the large foramen and below it the flattened inner surface of the coalesced deltidial plates. On either side are the elongate teeth. The division of the hinge-plate into an anterior and posterior portion is seen, the former taking the form of a crescent, its horns lying back upon the inner surface of the deltarium; this is connected laterally with the socket-walls and anteriorly with the anterior tent-shaped portion of the plate, which consists of two deep and broad lateral lamellæ resting on the bottom of the valve, united above by a deeply concave horizontal plate. The divergent and greatly elevated crural processes arise from the anterior angles formed by the union of these plates. In this figure the anterior portion of this apparatus is considerably foreshortened. $\times 10$:

Figs. 3, 4. Dorsal and profile views of a specimen with coarse surface plications.

Fig. 6. The umbonal portion of an external cast; showing the maximum development of the foraminal tube which is but a slightly introverted lamina. The drawing was also intended to show the hinge-line, the coalesced deltaria and the aliform cardinal expansions of the brachial valve, but as the figure is imperfect a corrected cut of the specimen is here introduced.

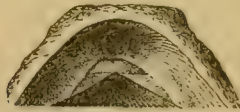


Fig. 10. The detached brachidium, viewed from the ventral side; showing the attachment of the crura to the primary lamellæ, the form of the jugum, its long, straight, bifurcate stem and the shape of the spiral cones. $\times 2$.

St. Louis group. *Spergen Hill, Indiana*.

EUMETRIA VERA, var. COSTATA, Hall.

Fig. 5. A dorsal view of a specimen from which the shell has partially exfoliated exposing the muscular impression on the brachial valve.

Chester limestone. *Chester, Illinois*.

Fig. 11. The interior of the umbonal portion of the brachial valve; showing the posterior horns of the hinge-plate, the posterior, the concave median plate and the elongate, narrow dental sockets. $\times 3$.

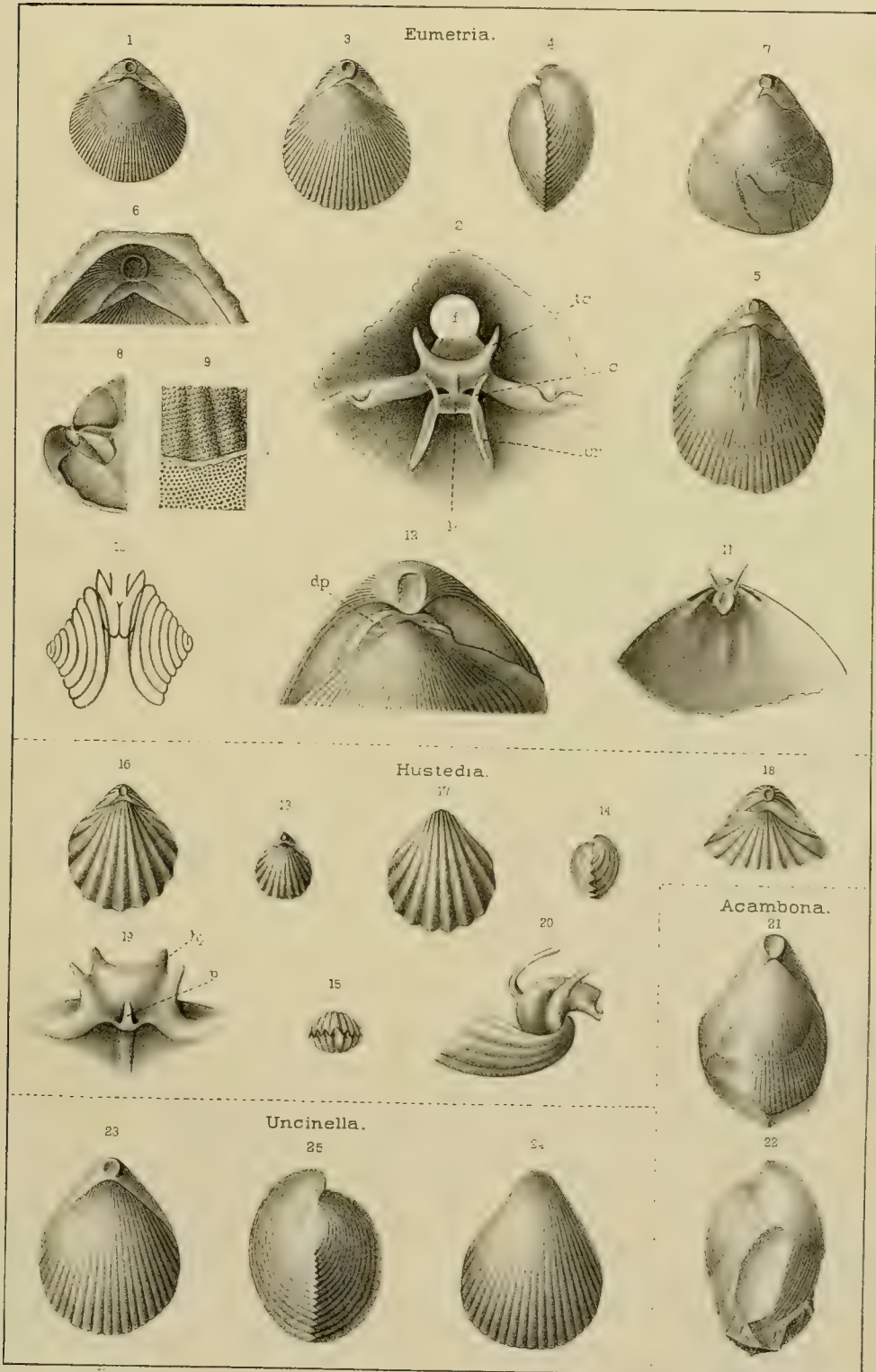
Chester limestone. *Crittenden county, Kentucky*.

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EUMETRIA? OSAGENSIS, Swallow.

Fig. 7. A dorsal view of an imperfect example.

Fig. 9. A portion of the exterior of the shell, enlarged. The lower part of the figure represents the punctations of the outer surface where it has been exposed and somewhat weathered; above is the surface of one of the inner layers covered with fine pustules. $\times 5$.

Choteau limestone. *Pike county, Missouri.*

EUMETRIA VERA, Hall.

Fig. 8. The umbonal portion of a specimen which has been broken longitudinally nearly in the median axis. On the upper portion is exposed the surface of the more distant of the two crural plates, flattened below by the transverse concave plate and the upward extension of the nearer of the crural plates. The outer shell is retained about the beak of the pedicle-valve.

Fig. 12. The umbonal portion of an old shell enlarged to show the thickening of the deltarium, which have become conspicuously protuberant. This thickening has been accompanied by a similar growth on the cardinal expansions of the brachial valve. $\times 2$.

Chester limestone. *Crittenden county, Kentucky.*

HUSTEDIA, HALL.

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HUSTEDIA MORMONI, Marcou.

Figs. 13, 14, 15. Dorsal, profile and anterior views of a normal specimen.

Figs. 16, 17. Enlarged views of a similar example. $\times 2$.

Fig. 18. An enlargement of the umbonal region; showing the coalesced deltarium. $\times 5$.

Fig. 19. A preparation of the hinge-plate; showing the elevation of the large recurved central part, the crural lobes and the projection of the anterior ligulate process. $\times 5$.

Fig. 20. The same viewed in profile.

Coal measures. *Near Kansas City, Missouri.*

ACAMBONA, WHITE.

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ACAMBONA PRIMA, White.

Figs. 21, 22. Dorsal and profile views of an incomplete specimen which is regarded as belonging to this species.

Burlington limestone. *Burlington, Iowa.*

UNCINELLA, WAAGEN.

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UNCINELLA TYPICA, Waagen.

Figs. 23, 24, 25. Dorsal, profile and ventral views of a typical example. (WAAGEN).

Permo-carboniferous. *Salt Range, India.*

PLATE 38.

- | | |
|--|---|
| <p>Legend: t. Teeth.
 dp. Deltaria.
 c. Crura.
 c'. Lateral divisions of hinge-plate.
 dt. Foraminal sheath.</p> | <p>hp. Hinge-plate.
 l. Stem of jugum.
 ub. Umbonal blades.
 a. Adductor scars.
 r. Diductor scars.</p> |
|--|---|

TREMATOSPIRA, HALL.

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TREMATOSPIRA CAMERA, Hall.

- Fig. 1. Ventral view of a rather large specimen.
 Fig. 2. Ventral view of a preparation showing by translucence the structure of the brachidium. $\times 3$.
Niagara group. Lockport, N. Y.

TREMATOSPIRA MULTISTRIATA, Hall.

- Figs. 3, 4. Dorsal and ventral views of a normal example.
 Fig. 5. A preparation showing one of the spiral cones, the form of the jugum and the mode of attachment of primary lamellæ and crura.
 Fig. 6. The central cardinal portion of the pedicle-valve, viewed from the apex; showing the foramen, teeth and concave, coalesced deltaria.
 Fig. 7. A similar portion of the brachial valve; showing the elevation of the divisions of the hinge-plate, the formation of a small median callosity, the constriction at its base and the striated basal callosity. $\times 3$.
 Fig. 8. Another view of the hinge-plate; showing its deep median excavation. $\times 3$.
Lower Helderberg group. The Helderbergs, N. Y.

TREMATOSPIRA HIPPOLYTE, Billings.

- Fig. 9. Dorsal view of the original example.
Lower Helderberg group. Square Lake, Maine.

TREMATOSPIRA SIMPLEX, Hall.

- Fig. 10. Dorsal view of a normal example. $\times 2$.
 Fig. 11. An enlargement of the surface; showing the pustules of the outer laminæ.
Lower Helderberg group. Decatur county, Tennessee.

TREMATOSPIRA COSTATA, Hall.

- Fig. 12. Dorsal view of a large example.
Lower Helderberg group. The Helderbergs, N. Y.

PARAZYGA, HALL.

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PARAZYGA HIRSUTA, Hall.

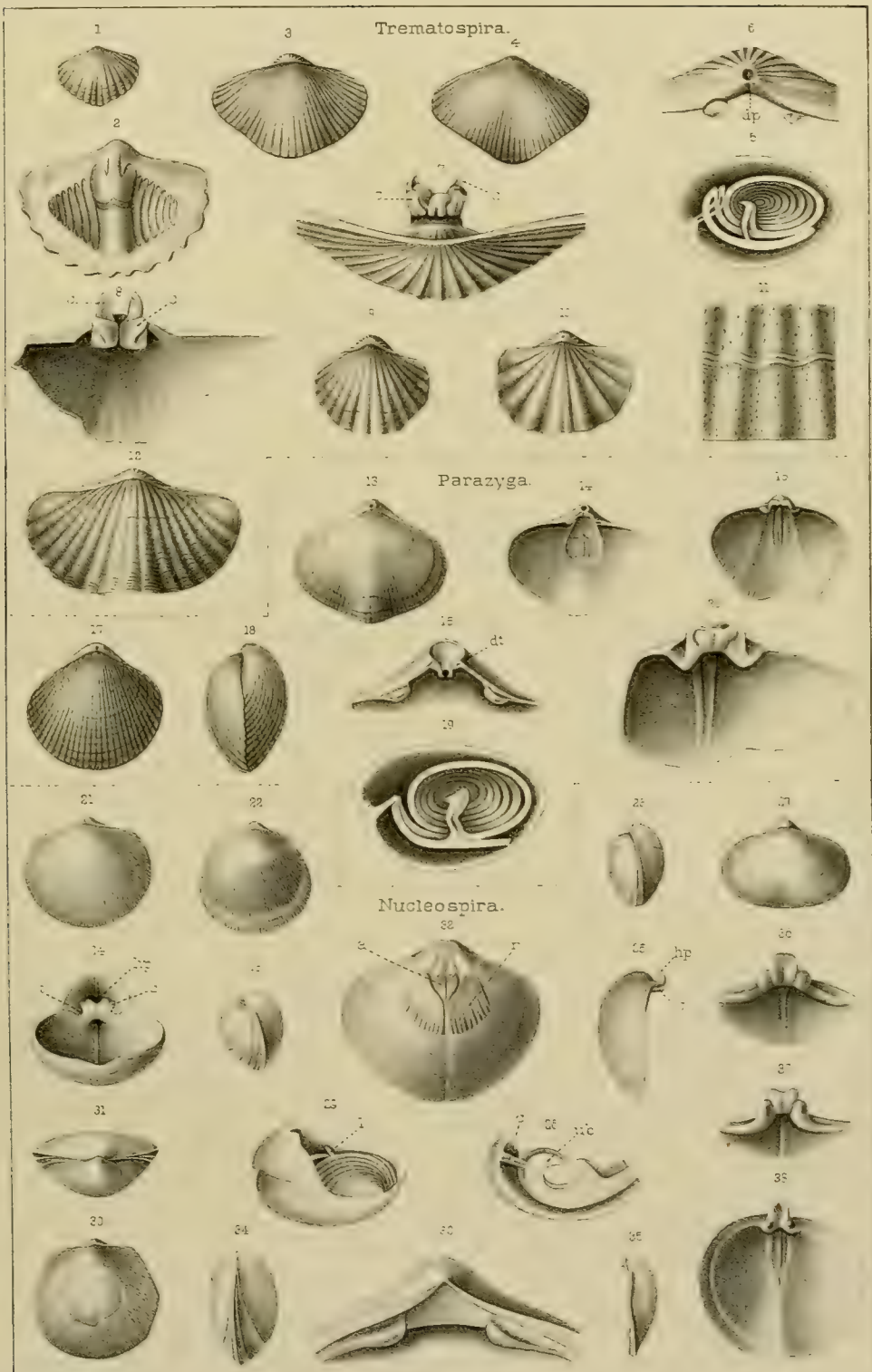
- Fig. 13. Dorsal view of a normal shell, deprived of its surface spinules.
 Fig. 14. The interior of the pedicle-valve; showing the muscular area.
 Fig. 15. The interior of the brachial valve; showing the hinge-plate.
 Fig. 16. The interior of the rostral region of the pedicle-valve; showing the pedicle-sheath. $\times 3$.
Hamilton group. Western New York.

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PARAZYGA DEWEYI, Hall.

Figs. 17, 18. Dorsal and profile views of the original specimen.

Fig. 19. A preparation showing the form of the jugum and mode of attachment of the primary lamellæ and crura.

Fig. 20. A portion of the brachial valve; showing the form of the hinge-plate.

Lower Helderberg group. *The Helderbergs, N. Y.*

NUCLEOSPIRA, HALL.

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NUCLEOSPIRA PISUM, Sowerby.

Fig. 21. A dorsal view; showing the fine surface spinules. $\times 2$.

Wenlock shale. *England.*

NUCLEOSPIRA VENTRICOSA, Hall.

Fig. 22. A dorsal view of a shell retaining the epidermal spinules over a portion of its surface. $\times 2$.

Fig. 23. Profile view of a comparatively large individual denuded of its spines.

Fig. 24. The interior of the brachial valve, with a portion of the pedicle-valve adhering, viewed from in front; showing the elevation and lobation of the hinge-plate, and the median septum. $\times 2$.

Fig. 25. A profile of the brachial valve; showing the recurved hinge-plate.

Fig. 26. A preparation showing the broad umbonal blades of the primary lamellæ, their attachment to the crura, and also the lateral branches of the jugum, the upright stem being broken off. $\times 3$.

NUCLEOSPIRA ELEGANS, Hall.

Figs. 27, 28. Dorsal and profile views of a normal specimen.

Lower Helderberg group. *Cherry Valley, N. Y.*

Fig. 29. A preparation exposing, by the removal of the pedicle-valve, the structure of the brachidium. At (*l*) is the projecting upright stem of the jugum.

Lower Helderberg group. *Schoharie, N. Y.*

NUCLEOSPIRA CONCINNA, Hall.

Fig. 30. A dorsal view of an average specimen retaining in part the surface spines.

Fig. 31. A cardinal view of conjoined valves.

Fig. 32. An internal cast of the pedicle-valve; showing the adductor and diductor scars. $\times 2$.

Fig. 33. An enlargement of the cardinal portion of the pedicle-valve; showing the concave and coalesced deltaria. $\times 5$.

Fig. 34. Profile view of conjoined valves.

Fig. 35. Profile view of the brachial valve; showing the projection of the hinge-plate.

Hamilton group. *Western New York.*

Fig. 36. A view of the hinge-plate; showing its concave surface and strong crural lobes. $\times 3$.

Fig. 37. The same specimen viewed from in front; showing the elevation of the plate.

Corniferous limestone. *Columbus, Ohio.*

Fig. 38. The interior of the brachial valve; showing the hinge-plate and adductor scars. $\times 2$.

Hamilton group. *Falls of the Ohio.*

PLATE 39.

- Legend: t. Teeth. a. Adductor scars.
b. Dental sockets. r. Diductor scars.
△ Delthyrium. j. Cardinal process.

ANOPLOTHECA, SANDBERGER.

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ANOPLOTHECA VENUSTA, Schnur.

- Figs. 1, 2. Ventral and dorsal views of an average specimen, enlarged.
Fig. 3. An internal cast of the pedicle-valve enlarged; showing the diductor scars and vascular impressions.
Fig. 4. The interior of a brachial valve enlarged; showing the cardinal process and muscular impressions.
Fig. 5. An enlarged view of a specimen; showing by the removal of a portion of the pedicle-valve, the spiral cones, their form and direction.
Middle Devonian. *Eifel, Germany.*
(Figs. 1, 2, SCHNUR; 3, 4, 5, SANDBERGER.)

ANOPLOTHECA LEPIDA, Goldfuss.

- Fig. 6. Dorsal view of a normal example. $\times 5$.
Fig. 7. The interior of a portion of the pedicle-valve; showing the teeth resting on the thickened shell-wall and the median septum grooved for the reception of the extremity of the jugum.
Middle Devonian. *Gerolstein, Eifel.*

CÆLOSPIRA, HALL.

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CÆLOSPIRA CONCAVA, Hall.

- Fig. 8. Ventral view of an average example. $\times 2$.
Fig. 9. Dorsal view of a similar specimen. $\times 2$.
Fig. 10. The interior of a brachial valve; showing the character of the cardinal process and socket-walls and the median thickening between the muscular impressions. $\times 3$.
Lower Helderberg group. *Near Clarksville, N. Y.*

CÆLOSPIRA CAMILLA, Hall.

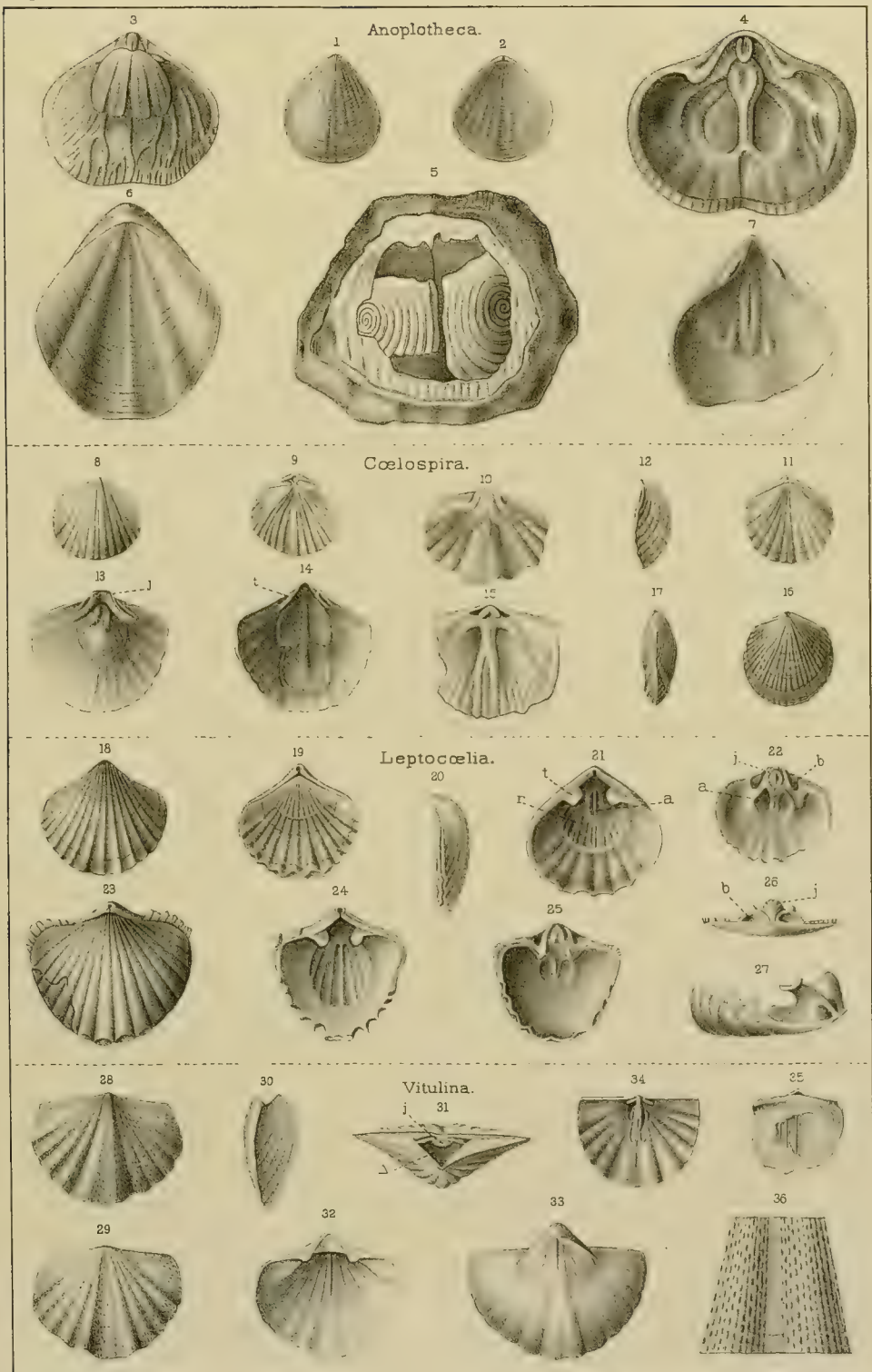
- Figs. 11, 12. Dorsal and profile views of a typical specimen. $\times 2$.
Fig. 13. The interior of a brachial valve; showing the elevated and somewhat recurved hinge-plate. $\times 4$.
Fig. 14. The interior of a pedicle-valve; showing the open delthyrium teeth and muscular impressions. $\times 4$.
Corniferous limestone. *Caldonia, N. Y.*

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Plate 39.



CÆLOSPIRA PLANO-CONVEXA, Hall.

Fig. 15. The interior of a brachial valve; showing the form of the cardinal process and the thickened median ridge. $\times 2$.

Figs. 16, 17. Dorsal and profile views of an average example.
Clinton group. *Hamilton, Ontario.*

LEPTOCÆLIA, HALL.

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LEPTOCÆLIA FLABELLITES, Conrad.

Figs. 18, 19, 20. Ventral, dorsal and profile views of an average example.

Fig. 21. The interior of a pedicle-valve; showing the teeth and muscular impressions.

Fig. 22. The interior of a brachial valve; showing the cardinal process, dental sockets and muscular area.

Oriskany sandstone. *Cumberland, Maryland.*

LEPTOCÆLIA FIMBRIATA, Hall.

Fig. 23. Dorsal view of an average specimen. $\times 2$.

Fig. 24. The interior of a pedicle-valve; showing the teeth and muscular area.
 $\times 2$.

Fig. 25. The interior of a brachial valve; showing the articulating apparatus.
 $\times 2$.

Fig. 26. Cardinal view of a brachial valve; showing the elevation of the cardinal process and dental sockets. $\times 2$.

Fig. 27. Profile view of a brachial valve; showing the elevation of the crura.
 $\times 3$.

Oriskany sandstone. *Cumberland, Maryland.*

VITULINA, HALL.

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VITULINA PUSTULOSA, Hall.

Fig. 28. The exterior of a pedicle-valve. $\times 3$.

Fig. 29. Similar view of a brachial valve. $\times 3$.

Fig. 30. Profile of conjoined valves. $\times 3$.

Fig. 31. Cardinal view of conjoined valves; showing the area on each valve, the open delthyrium and the cardinal process. $\times 3$.

Fig. 32. The interior of a pedicle-valve. $\times 3$.

Fig. 33. An internal cast of the pedicle-valve; showing the muscular area.
 $\times 3$.

Hamilton group. *Western New York.*

Fig. 34. The interior of a brachial valve; showing the cardinal process and low crural plates.

Middle Devonian. *Eréré, Brazil.*

Fig. 35. Ventral view of a preparation; showing three volutions of the spiral cone which is directed toward the lateral margin of the valves.

Hamilton shales. *Alden, N. Y.*

Fig. 36. An enlargement of the external surface; showing the radiating rows of elongate pustules.

Hamilton shale. *Western New York.*

PLATE 40.

Legend: dp. Deltaria.

t. Teeth.

S. Impression of primary
lamellæ.

j. Cardinal process.

a. Adductor scars.

r. Diductor scars.

CYCLOSPIRA, HALL.

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CYCLOSPIRA BISULCATA, Emmons.

Figs. 1, 2, 3. Dorsal, profile and ventral views of a specimen bearing a marginal plication in the sinus of the brachial valve. $\times 2$.

Trenton limestone. *Watertown, N. Y.*

PROTOZYGA, HALL.

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PROTOZYGA EXIQUA, Hall.

Figs. 4, 5. Dorsal and ventral views of an average specimen. $\times 2$.

Trenton limestone. *Watertown, N. Y.*

GLASSIA, DAVIDSON.

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GLASSIA ROMINGERI, Hall.

Figs. 6, 7, 8. Dorsal, ventral and profile views of the original specimen; showing the smooth bilobed exterior. $\times 2$.

Fig. 9. A preparation showing the introverted coils and the direction of the jugum. $\times 3$.

Trenton limestone. *From the drift near Ann Arbor, Michigan.*

HALLINA, N. H. WINCHELL AND SCHUCHERT.

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HALLINA SAFFORDI, N. H. Winchell and Schuchert.

Figs. 10, 11, 12. Dorsal, ventral and profile views of a typical example. $\times 5$.

Trenton limestone. *Lebanon, Tennessee.*

ZYGOSPIRA, HALL.

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ZYGOSPIRA MODESTA, Say.

Figs. 13, 14. Dorsal and profile views. $\times 3$.

Fig. 15. The interior of a brachial valve; showing the bilobed cardinal process. $\times 2$.

Hudson River group. *Near Cincinnati, Ohio.*

Fig. 16. An enlargement of the cardinal region; showing the deltidial plates and the encroachment of the foramen on the substance of the valve. The sharp definition of the cardinal area in this figure is erroneous.

Fig. 19. A portion of the specimen represented in figure 15 enlarged to show more distinctly the structure of this process. $\times 6$.

Hudson River group. *Versailles, Indiana*.

ZYGOSPIRA PUTILLA, Hall.

Figs. 17, 18. Dorsal and ventral views of a typical example. $\times 2$.

Hudson River group. *Pike county, Missouri*.

ZYGOSPIRA RECURVIROSTRA, Hall.

Fig. 20. Profile view of an average example. $\times 3$.

Trenton limestone. *Savannah, Illinois*.

Fig. 21. Dorsal view of a more finely plicated shell. $\times 2$.

Trenton horizon. *Frankfort, Kentucky*.

ZYGOSPIRA CINCINNATIENSIS, Meek.

Figs. 22, 23. Dorsal and ventral views of the exterior. $\times 2$.

Hudson River group. *Cincinnati, Ohio*.

ZYGOSPIRA KENTUCKIENSIS, James.

Figs. 24, 25. Dorsal and profile views of a characteristic example, natural size.

Hudson River group. *Oldham county, Kentucky*.

CATAZYGA, HALL.

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CATAZYGA HEADI, Billings.

Figs. 26, 27, 28. Dorsal, profile and cardinal views of the exterior.

Hudson River group. *Near Ottawa, Canada*.

Fig. 33. The interior of a portion of the pedicle-valve; showing the deep muscular scar.

Hudson River group. *Waynesville, Indiana*.

CATAZYGA HEADI, var. ANTICOSTIENSIS, Billings.

Figs. 29, 30, 31. Dorsal, ventral and profile views of an average example.

Hudson River group. *Collingwood, Ontario*.

CATAZYGA HEADI, var. BOREALIS, Billings.

Fig. 32. Dorsal view; showing the form of the shell.

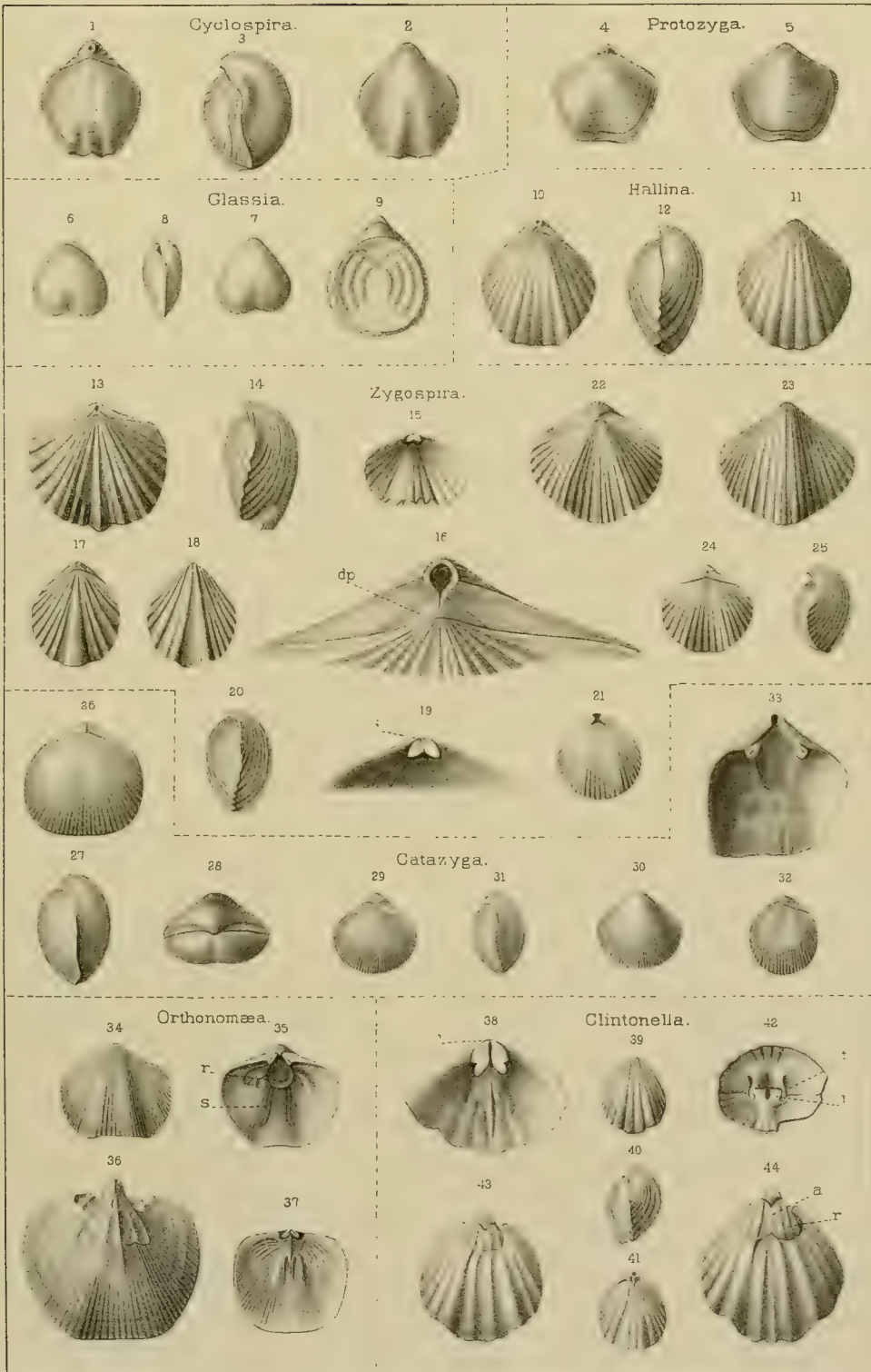
Anticosti group. *Island of Anticosti*.

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Plate 40.



ORTHONOMÆA, HALL.

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ZYGOSPIRA (ORTHONOMÆA) ERRATICA, Hall.

Fig. 34. The exterior of a pedicle-valve; showing its contour and fine surface plication.

Hudson River group. *Hamilton, Ontario.*

Fig. 35. The interior of a pedicle-valve; showing the open delthyrium, the deep posterior muscular scar, the lateral impressions at the sides of this scar and over the median portion of the valve, traces of the primary lamellæ.

Fig. 36. An internal cast of the pedicle-valve; showing the muscular scars. $\times 2$.

Fig. 37. The interior of the brachial valve; showing the bilobed cardinal process, muscular and vascular impressions.

(Figs. 35 and 37 from gutta percha squeezes.)

Hudson River group. *Erratic blocks of central New York.*

CLINTONELLA, HALL.

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CLINTONELLA VAGABUNDA, Hall.

Fig. 38. The interior of the umbonal portion of the brachial valve; showing the divided hinge-plate and low median ridge. $\times 3$.

Figs. 39, 40, 41. Ventral, profile and dorsal views of a specimen from which the brachial valve is removed.

Fig. 42. The interior of the umbonal region of conjoined valves, viewed from in front; showing the mode of articulation and the bilobed cardinal process. $\times 3$.

Figs. 43, 44. Ventral views of two internal casts; showing the muscular area crossed by the plications of the shell.

Clinton group. *Drift of western New York.*

PLATE 41.

Legend: dp. Deltaria. c. Crural bases.
 hp. Hinge-plate. b. Dental sockets.
 P. Delthyrium. sr. Crenulated ridge in sockets.
 p. Scar of pedicle-muscle.

ATRYPINA, HALL.

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ATRYPINA DISPABILIS, Hall.

Figs. 1, 2. Dorsal and ventral views of an average example. $\times 2$.
Niagara group. *Waldron, Indiana.*

ATRYPINA IMBRICATA, Hall.

Fig. 3. The interior of a pedicle-valve; showing the concave deltidial plates.
 × 2.

Fig. 4. The interior of a brachial valve; showing the bilobed cardinal process. $\times 2$.

Fig. 5. Cardinal view of the same specimen. $\times 2\frac{1}{2}$.
Lower Helderberg group. Near Clarksville, N. Y.

ATRYPINA CLINTONI, Hall.

Fig. 6. The interior of an incomplete brachial valve; showing the bilobed cardinal process and median muscular ridge. $\times 3$.
Clinton group. *Drift of Western New York.*

ATRYPA, DALMAN.

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ATRYPA RETICULARIS, Linné.

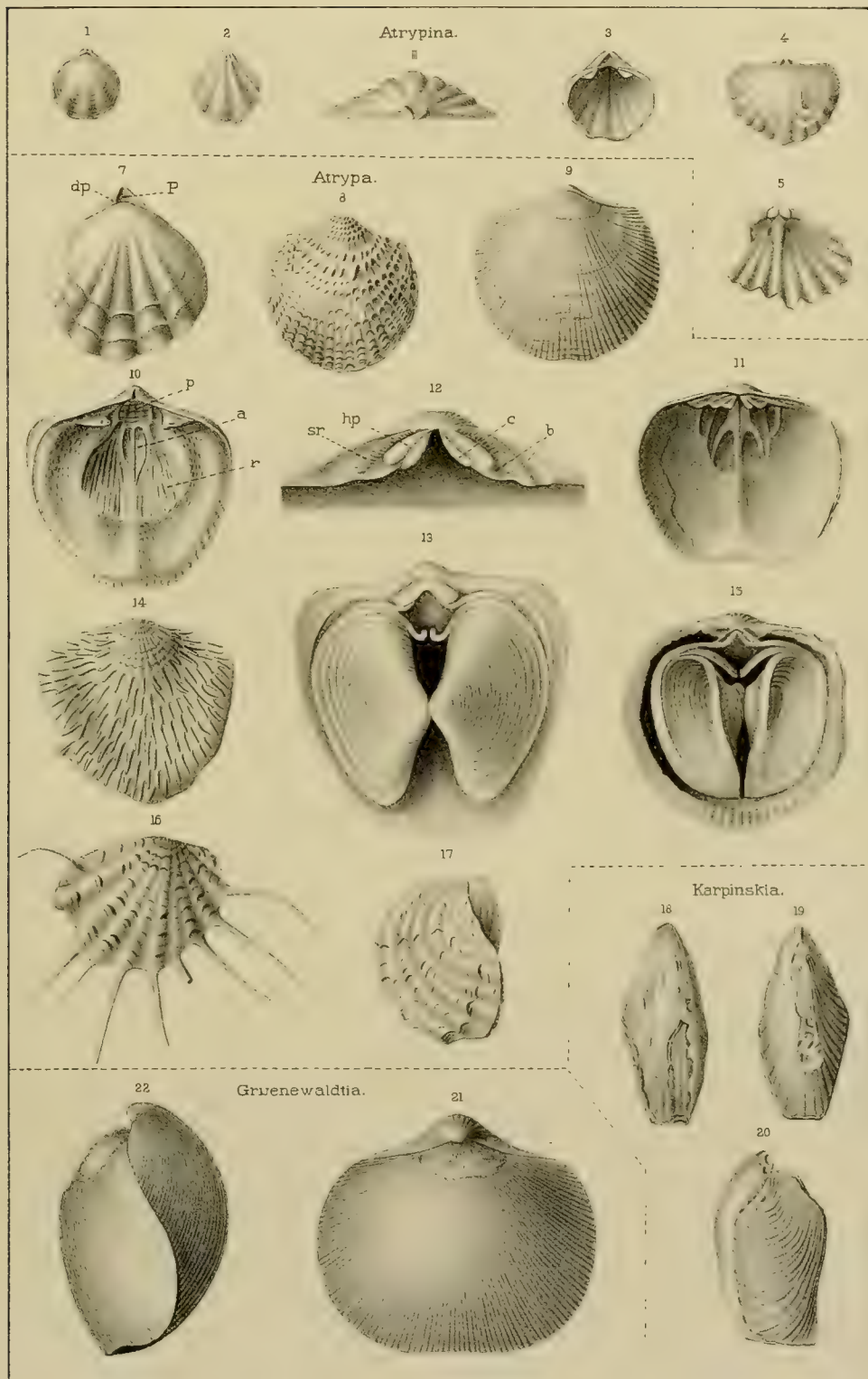
Fig. 7. Dorsal view of the youngest individual observed; showing the slight convexity of the brachial valve in the umbonal region, its general depression anteriorly, low median sinus, few plications, erect beak and incipient deltaria. $\times 10$.

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Plate 41.



Philip Ast lith.

James B Lyon, State Printer.

Fig. 8. Ventral view of a mature individual from the same locality; showing the extensions of the concentric lamellæ.

Niagara group. *Waldron, Indiana.*

Fig. 9. Dorsal view of a finely plicate shell.

Fig. 10. The interior of a pedicle-valve; showing the broad pedicle-cavity, widely separated teeth, pedicle, adductor and diductor muscular scars, ovarian markings and crenulated margins.

Fig. 11. The interior of a brachial valve; showing the structure of the hinge-plate, dental sockets and muscular scars.

Hamilton group. *Western New York.*

Fig. 12. The cardinal portion of the brachial valve enlarged; showing the reduced and completely divided hinge-plate, and the broad dental sockets traversed by a crenulated median ridge. $\times 3$.

Hamilton group. *Clarke county, Indiana.*

Fig. 13. A preparation exposing, by the removal of the brachial valve, the brachidium of a large individual. The spiral cones have their bases parallel to the surface of the pedicle-valve and their apices directed upward and inward into the cavity of the convex brachial valve. The figure shows the laterally appressed form of the cones, the great width and anterior extension of the primary lamellæ, the attachment of the latter to the crura and the discrete, recurved branches of the jugum.

Chemung group. *Haskinsville, N. Y.*

ATRYPA SPINOSA, Hall.

Fig. 14. The exterior of the pedicle-valve; showing the extension of the concentric lamellæ into well defined spinules.

Hamilton group. *Moscow, N. Y.*

ATRYPA ASPERA, Schlotheim, var. OCCIDENTALIS, Hall.

Fig. 15. A preparation of the brachidium exposed by the removal of the pedicle-valve.

Fig. 17. Profile view of the exterior; showing the gibbosity of the brachial valve and the coarse plications.

Upper Devonian. *Independence, Iowa.*

ATRYPA HYSTRIX, Hall.

Fig. 16. The exterior of a pedicle-valve, with coarse ribs, strong concentric lamellæ and stout long marginal spines.

Chemung group. *Near Bath, N. Y.*

KARPINSKIA, TSCHERNYSCHIEW.

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KARPINSKIA CONJUGULA, Tschernyschew.

Figs. 18, 19, 20. Ventral, dorsal and profile views of the exterior.
Lower Devonian. *Ural Mountains, Russia.*

GRUENWALDTIA, TSCHERNYSCHIEW.

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GRUENWALDTIA LATILINGUIS, Schnur.

Figs. 21, 22. Dorsal and profile views; showing the contour and external markings.
Middle Devonian. *Gerolstein, Germany.*

PLATE 49.

Legend.	dp. Dental plates.	VA. Cardinal area.
	△ Delthyrium.	pm. Pedicle-muscle.
	s. Median septum.	a. Adductor scars.
	t. Teeth.	r. Diductor scars.
	c. Crural bases.	

RHYNCHONELLA, FISCHER DE WALDHEIM.

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RHYNCHONELLA LOXIA, Fischer de Waldheim.

Figs. 1, 2. Anterior and profile views of a normal mature individual, retaining the smooth external surface, and showing the contour of the shell.

Fig. 3. Cardinal view of an internal cast; showing the cavity of the dental plates and median septum.

This is the type of the genus RHYNCHONELLA.

Upper Jurassic. *Charaschowa, Russia.*

PROTORHYNCHA, HALL.

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PROTORHYNCHA LEQUIRADIATA, Hall.

Fig. 4. An internal cast of a larger pedicle-valve; showing a well defined median sinus and a very restricted muscular scar in the umbonal region. $\times 2$.

Fig. 5. An internal cast of the brachial valve; showing the length of the median septum. $\times 2$.

Fig. 6. The cardinal portion of the brachial valve enlarged; showing a clearly defined cardinal area, oblique dental sockets, the broad, rather ill-defined hinge-plate, with a median cavity whose lateral walls are continuous with the median septum. $\times 3$.

Clinton group. *New Hartford, N. Y.*

ORTHORYNCHULA, HALL.

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ORTHORYNCHULA LINNEYI, Nettelroth.

Figs. 7-9. Dorsal, ventral and profile views of the exterior of an average example; showing contour and character of plication.

Fig. 10. The central portion of the cardinal region, enlarged; showing the sharply defined cardinal area and the open delthyrium. $\times 3$.

Hudson River group. *Nashville, Tennessee.*

RHYNCHOTREMA, HALL.

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RHYNCHOTREMA CAPAX, Conrad.

Figs. 11, 12. Dorsal and front views of a somewhat gibbous adult; showing the character of the plication and the fine concentric lineation.

Hudson River group. *Frankfort, Kentucky.*

Fig. 13. The interior of a pedicle-valve; showing the broad, concave deltidial plates, in contact for their entire length along the median line, greatly thickened and consolidated with the bottom of the valve beneath; also the recurved teeth resting upon the thickened lateral walls, the pair of shallow depressions in the umbonal region and the deep diductor scar in the middle of the valve, which has been greatly encroached upon by the umbonal thickening of the shell.

Fig. 14. An enlargement of the umbonal portion of the same specimen. The small cavity at the base of the deltidial plates is the inner opening of the pedicle-passage which was functional at this advanced growth-stage of the shell, its outer opening being on the back of the umbo, considerably removed from the beak, and connected with the apex by a groove whose margins are shown in the figure.

Fig. 15. An enlargement of the umbonal portion of a brachial valve; showing the deflection of the vertical septiform cardinal process, the character of the hinge-plate, socket-walls, sockets and crural apophyses.

Figs. 13, 14, 15 are from the specimens upon which the characters of the genus were originally established.

Hudson River group. *Iron Ridge, Wisconsin.*

Fig. 16. The interior of an old brachial valve; showing the deflection of the cardinal process and the thickened hinge-plate.

Hudson River group. *Richmond, Indiana.*

RHYNCHOTRETA, HALL.

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RHYNCHOTRETA CUNEATA, Dalman, var. AMERICANA, Hall.

Figs. 17, 18. Dorsal and profile views of an average example; showing the contour of the shell and the character of the plication.

Niagara group. *Waldron, Indiana.*

Fig. 19. The cardinal region of an adult specimen, enlarged, showing the unusual size of the deltidial plates, their outward flexion along the median suture, the apical and encroaching position of the foramen.

* 5. (BEECHER and CLARKE.)

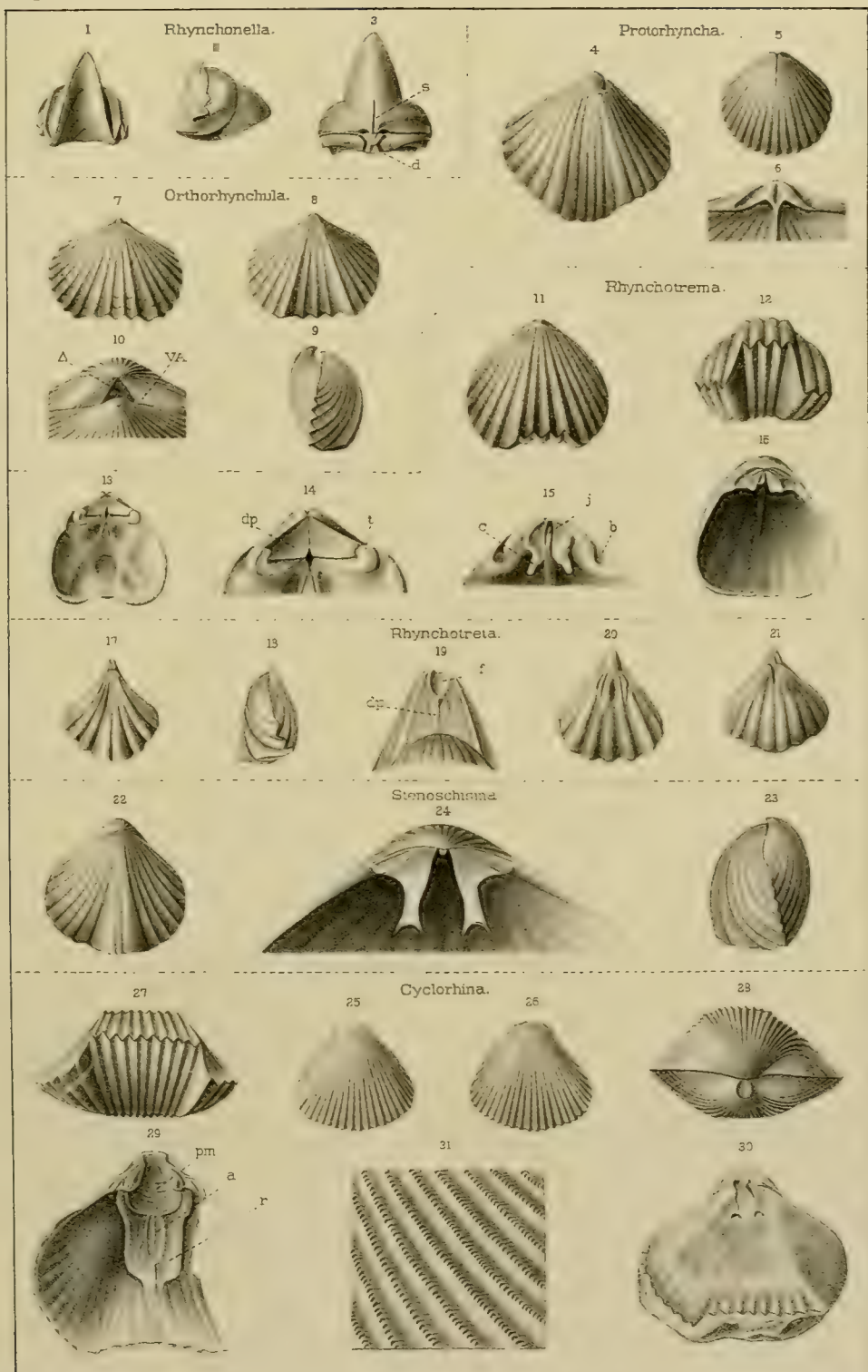
Niagara group. *Waldron, Indiana.*

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Plate 42.



Philip Ast lith.

James T. Lyon del.

Figs. 20, 21. Ventral and dorsal views of an internal cast of conjoined valves; showing, in figure 36, the impression of the pedicle muscle, the diductor and adductor scars bounded by divergent ridges, and, in figure 37, the cast of the delthyrial cavity and the extent of the median septum.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

STENOSCHISMA, CONRAD.

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STENOSCHISMA FORMOSA, Hall.

Figs. 22, 23. Dorsal and profile views of the exterior.

Fig. 24. Enlargement of the hinge-plate; showing its deep median division, minute cardinal process, flat crural lobes and concave crura. $\times 4$.

Lower Helderberg group. *Albany county, N. Y.*

CYCLORHINA, HALL.

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CYCLORHINA NOBILIS, Hall.

Figs. 25, 26. Dorsal and ventral views of a young shell; showing the obtuse umbones, deeply truncated beak, straight cardinal line and low median fold and sinus.

Figs. 27, 28. Front and cardinal views of a mature individual.

Hamilton group. *Thedford, Ontario.*

Fig. 29. The interior of a pedicle-valve; showing the teeth and the scars of the pedicle, adductor and diductor muscles.

Fig. 30. A weathered specimen; showing the cavities occupied by the crura.

Hamilton group. *Darien, N. Y.*

Fig. 31. An enlargement of the external surface; showing the fine concentric lines which crenulate the crest of each plication. $\times 3$.

PLATE 43.

Legend: hp. Hinge-plate. a. Adductor scars.
 b. Dental sockets. r. Diductor scars.
 d. Spondylium. v. Vascular sinuses.
 j. Cardinal process. x. Callosities in the umbonal region.
 c. Crural bases.

CAMAROTÆCHIA, HALL.

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CAMAROTÆCHIA CONGREGATA, Hall.

- Figs. 1, 2, 3. Dorsal, ventral and cardinal views of a typical specimen.
Figs. 4, 5. Enlargements of the hinge-plate; showing its median division by an incipient spondylium and the crenulation of the dental sockets.
Fig. 9. Cardinal view of an internal cast; showing the cavities of the dental plates and median septum.
Hamilton group. *Sandy shales of Central New York.*

CAMAROTÆCHIA CONTRACTA, Hall.

- Fig. 6. An internal cast of the pedicle-valve; showing the muscular scars. $\times 3$
Hamilton group. *Near Cardiff, N. Y.*

CAMAROTÆCHIA ORBICULARIS, Hall.

- Fig. 7. An internal cast of the pedicle-valve; showing the adductor and diductor scars. $\times 3$.
Fig. 8. Cardinal view of an internal cast; showing the filling of the rostra cavity and the extent of the thickened median septum.
Chemung group. *Meadville, Pennsylvania.*

PIETHORHYNCHA, HALL.

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PLETHORHYNCHA SPECIOSA, Hall.

- Fig. 10. Cardinal view of the brachial valve of an old shell in which the entire hinge-plate has been greatly thickened and the apical portion, or cardinal process, resorbed and excavated.
Figs. 11, 14. Two views of the brachial valve; showing the thickened hinge-plate, bilobed cardinal process and strong median septum.
Fig. 12. The hinge-plate of a young shell; showing its median division and small cardinal process. $\times 2$.

Figs. 13, 15. Profile and cardinal views of a large entire individual; showing the robust form of the shell, its subquadrate transverse section, serrate margins and broad, somewhat concave cardinal slopes. The abrupt marginal extensions of the cardinal slopes of the pedicle-valve, fitting into corresponding excavations of the brachial valve, are the thickened teeth cemented to the walls of the valve throughout their entire extent and, at their summits only, fitted into the shallow sockets of the opposite valve.

Oriskany sandstone. *Cumberland, Maryland.*

LIORHYNCHUS, HALL.

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LIORHYNCHUS LIMITARIS, Hall.

Figs. 16, 17. Ventral and front views of a large specimen.

Marcellus shales (Stafford limestone). *Avon, N. Y.*

LIORHYNCHUS LAURA, Billings.

Fig. 18. Dorsal view of a rather elongate shell.

Figs. 19, 20. Two views of the hinge-plate and crura. $\times 4$.

Hamilton group. *Theford, Ontario.*

LIORHYNCHUS MESACOSTALIS, Hall.

Fig. 21. An internal cast of the brachial valve; showing the extent of the median septum, the elongate muscular scars and the absence of plications on the lateral slopes.

Chemung group. *Tompkins county, N. Y.*

LIORHYNCHUS QUADRICOSTATUS, Vanuxem.

Fig. 22. The exterior of a crushed and somewhat distorted pedicle-valve; showing the character of the plication.

Genesee shales. *Western New York.*

LIORHYNCHUS NEWBERRYI, Hall.

Fig. 23. An internal cast of the brachial valve; showing its fine and complete plication.

Upper Devonian. *Kelloggsville, Ohio.*

LIORHYNCHUS ROBUSTUS, Hall.

Fig. 24. Ventral view of an internal cast; showing the muscular scars, and the vascular sinuses radiating from the impressions left by an umbonal testaceous callosity.

Chemung group. *Steuben county, N. Y.*

PLATE 44.

- Legend: j. Cardinal process. a. Adductor scars.
 c. Crura. r. Diductor scars.
 v. Vascular sinuses.

WILSONIA (QUENSTEDT), KAYSER.

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WILSONIA SAFFORDI, Hall.

- Figs. 1, 2, 3. Dorsal, ventral and anterior views; showing the character of the exterior.
Fig. 4. Cardinal view of an internal cast of conjoined valves; showing the impressions left by the dental plates and the median septum. $\times 2$.
Fig. 5. The interior of a pedicle-valve; showing the teeth and the muscular area. $\times 2$.

Niagara group. *Perry county, Tennessee.*

UNCINULUS, BAYLE.

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UNCINULUS ABRUPTUS, Hall.

- Fig. 6. Cardinal view of a brachial valve; showing the dental sockets; bilobed cardinal process and the elevation of the crura. $\times 2$.
Fig. 7. The same viewed from above. $\times 2$.
Figs. 8, 9. Dorsal and front views of a typical example.

Lower Helderberg group. *Albany county, N. Y.*

HYPOTHYRIS, KING.

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HYPOTHYRIS VENUSTULA, Hall.

(= *Rhynchonella cuboides*, Sowerby.)

- Figs. 10, 11, 12. Cardinal, front and profile views of a typical specimen.
Fig. 13. Ventral view of an internal cast; showing the vascular sinuses.
Tully limestone. *Ovid, N. Y.*

PUGNAX, Hall.

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PUGNAX EXPLANATUS, McChesney.

- Figs. 14, 15, 16. Dorsal, profile and front views; from a sulphur cast of the original specimen.
Kaskaskia limestone. *Illinois.*

PUGNAX UTA, Marcou.

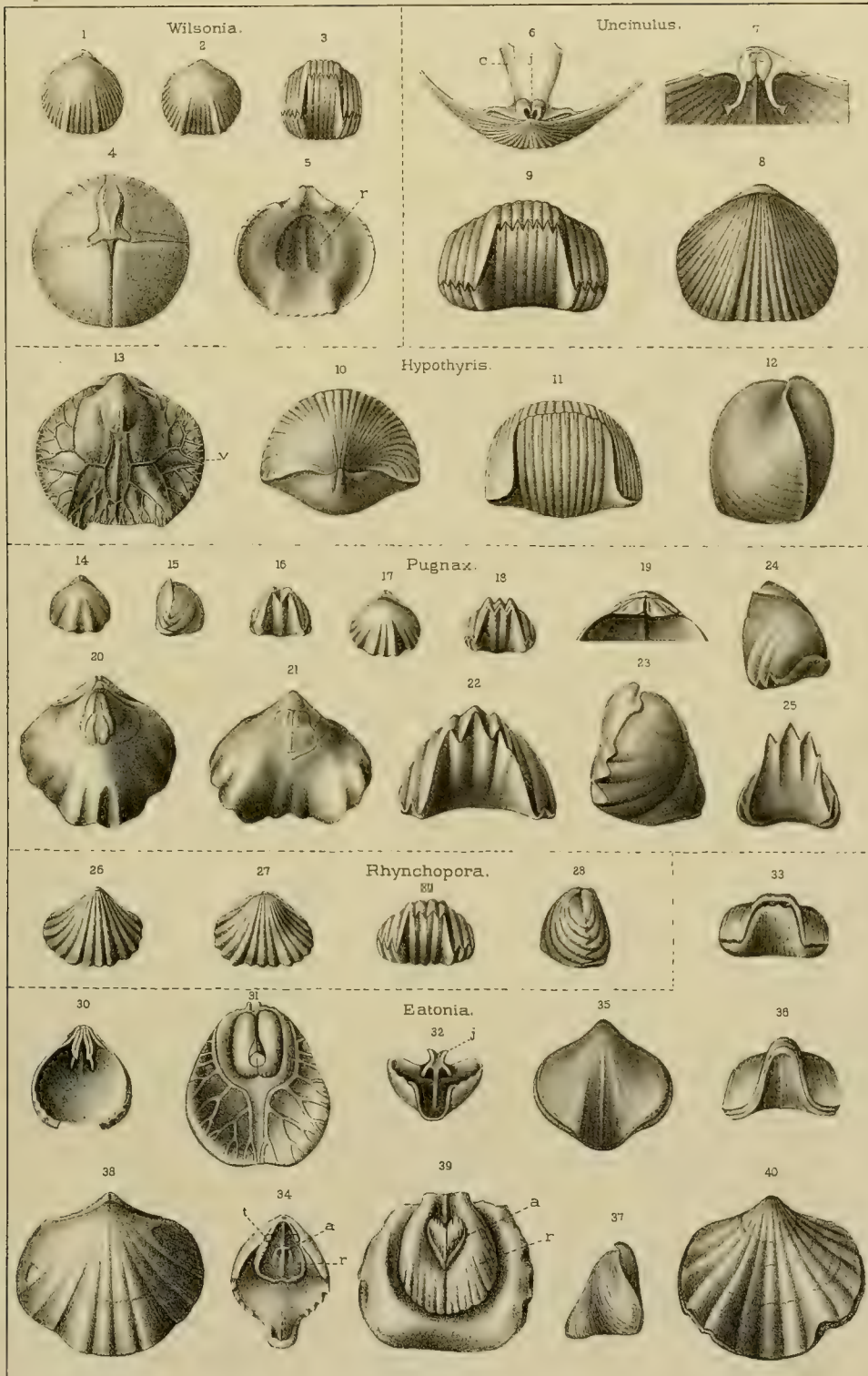
- Figs. 17, 18. Dorsal and front views of an average example.
Fig. 19. A portion of the interior of the brachial valve; showing the broad hinge-plate. $\times 3$.
Coal measures. *Manhattan, Kansas.*

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Plate 44.



PUGNAX PUGNUS, Sowerby.

Figs. 20, 21, 22, 23. Dorsal, ventral, front and profile views of an internal cast; showing the contour of the shell and the form of the muscular impressions.

Chemung group. *High Point, Naples, N. Y.*

PUGNAX ALTUS, Calvin.

Figs. 24, 25. Profile and front views of an example with highly-elevated median fold.

Middle Devonian. *Hackberry Grove, Iowa.*

RHYNCHOPORA, KING.

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RHYNCHOPORA PUSTULOSA, White.

Figs. 26, 27, 28, 29. Dorsal, ventral, profile and front views of a normal example.

Burlington limestone. *Burlington, Iowa.*

EATONIA, HALL.

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EATONIA PECULIARIS, Conrad.

Fig. 30. The interior of a brachial valve; showing the extent of the cardinal process.

Oriskany sandstone. *Cumberland, Maryland.*

Fig. 31. An internal cast of the pedicle-valve; showing the impressions of the adductor and diductor scars and the vascular sinuses. $\times 2$.

Fig. 32. The interior of a brachial valve viewed in profile from the front margin; showing the elevation of the cardinal process, its lobation and the elevation of the crura.

Oriskany sandstone. *Albany county, N. Y.*

Fig. 33. Front view of a specimen; showing the development of median fold and sinus and the dentate margins.

Lower Helderberg group. *The Helderbergs, N. Y.*

Fig. 34. The interior of a pedicle-valve; showing the open delthyrium, marginal teeth, large diductor scars, small adductors with strongly elevated posterior walls, the dentate shell margins and the lingulate extension of the median sinus.

Oriskany sandstone. *Cumberland, Maryland.*

EATONIA SINGULARIS, Vanuxem.

Fig. 35. Ventral view of a large shell.

Figs. 36, 37. Front and profile views of another example.

Lower Helderberg group. *Albany county, N. Y.*

EATONIA MEDIALIS, Vanuxem.

Figs. 38, 40. Dorsal and ventral views of a normal example.

Fig. 39. An internal cast of an old pedicle-valve with strong muscular scars.

Lower Helderberg group. *Albany county, N. Y.*

PLATE 45.

Legend: d. Spondylium. s'. Septa (brachial valve).
s. Septum (pedicle-valve). a. Adductor scars.

CAMAROPHORIA, KING.

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CAMAROPHORIA SUBTRIGONA, Meek and Worthen.

Fig. 1. Ventral view of an internal cast; showing the contour of the shell, the denticulate margins of the valves on the broad cardinal slopes, the sharply serrate anterior and lateral margins and the cavity left by the spondylium and median septum of the pedicle-valve.

Chert of the Burlington limestone. *Burlington, Iowa.*

Fig. 2. Internal cast of pedicle-valve; showing the form of the muscular impression.

Keokuk group. *Nauvoo, Illinois.*

CAMAROPHORIA SUBCUNEATA, Hall.

Fig. 3. A portion of the interior of the pedicle-valve, showing the spondylium supported by a median septum. The summits of the teeth have been broken, showing their lateral union with the walls of the shell. $\times 2$.

Fig. 4. Profile view of a mature and gibbous shell, showing the character of the plication and the broad, concave cardinal slopes.

St. Louis group. *Washington county, Indiana.*

CAMAROPHORELLA, HALL.

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CAMAROPHORELLA LENTICULARIS, White and Whitfield.

Fig. 5. An internal cast of the brachial valve; showing the impressions of spondylium and median septum. In this valve the spondylium is flat and the supporting septum penetrates it, extending for a short distance into the interior cavity of the shell. $\times 2$.

Fig. 6. A cardinal view of an internal cast of the pedicle-valve; showing the filling of the spondylium and the cavities left by the median septum and the oblique dental plates. $\times 2$.

Yellow sandstones of the Burlington group. *Burlington, Iowa.*

SYNTROPHIA, HALL.

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SYNTROPHIA LATERALIS, Whitfield.

Fig. 7. The exterior of a pedicle-valve; showing the long, straight hinge and broad median sinus.

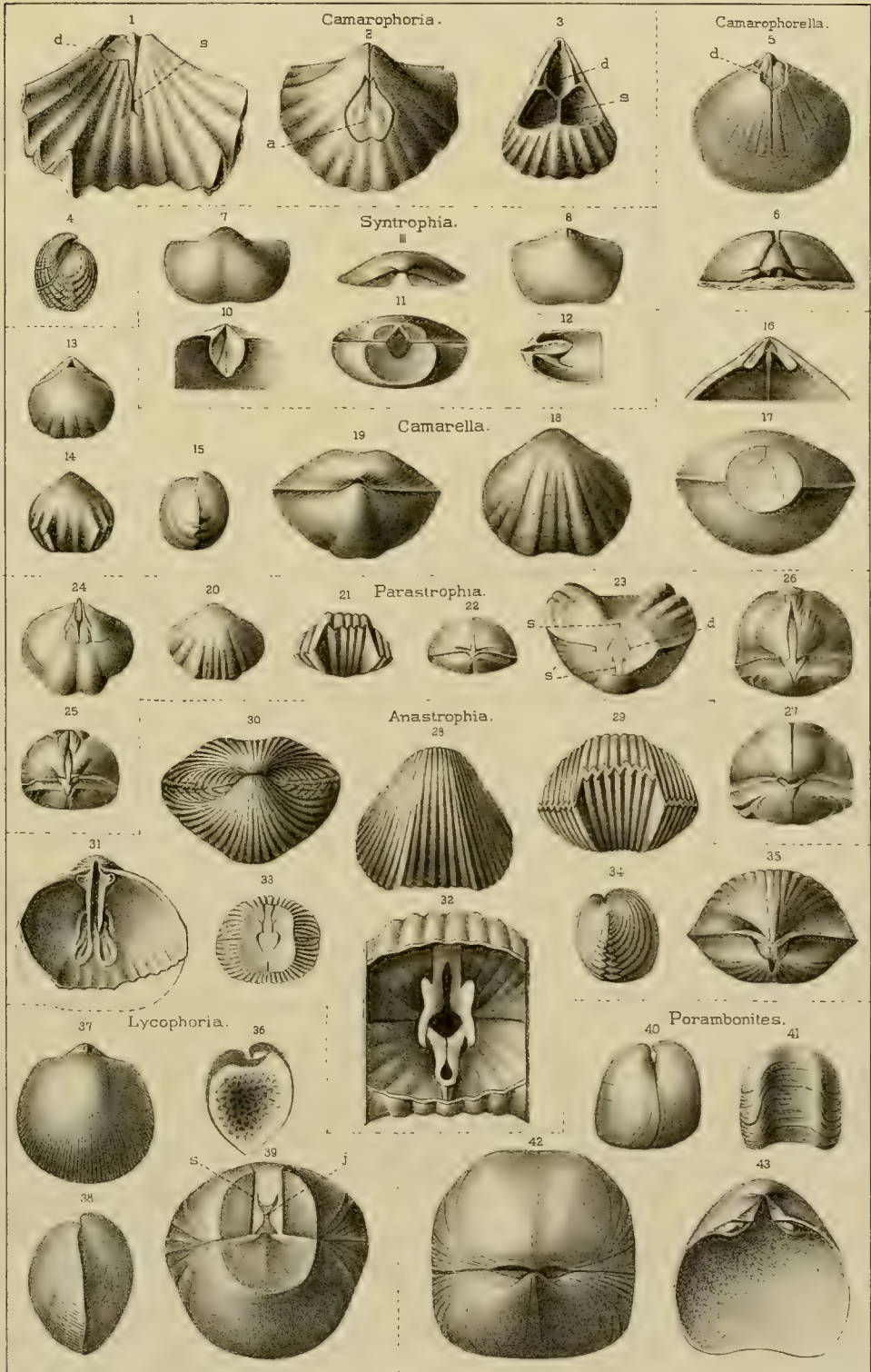
Fig. 8. The exterior of a brachial valve; showing the obscure median fold.

BRACHIOPODA.

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- Fig. 9. Cardinal view of the specimen represented in figure 7; showing the cardinal area.
- Fig. 10. A portion of the interior of the pedicle-valve; showing the complete spondylium and the division of its surface into median (adductor) and lateral (diductor) muscular areas. $\times 3$.
- Fig. 11. Cardinal view of conjoined valves which have been transversely sectioned in the umbonal region; showing the spondylium in both valves. The shell has been cut just in front of the supporting septa, the brachial valve being above. $\times 2$.
- Fig. 12. Oblique view of the specimen represented in figure 10; showing the elevation of the spondylium and the length of its supporting median septum.

Calciferous formation (Fort Cassin beds). *Fort Cassin, Vermont.*

CAMARELLA, BILLINGS.

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CAMARELLA VOLBORTHII, Billings.

- Figs. 13, 14, 15. Dorsal, ventral and profile views of a strongly plicated shell. $\times 2$.
- Fig. 16. The interior of the umbonal portion of the brachial valve; showing the small apical spondylium and the median septum. $\times 4$.
- Fig. 17. Cardinal view of conjoined valves which have been transversely sectioned in the umbonal region; showing the spondylium of the pedicle-valve and its median supporting septum. $\times 4$.

Black River limestone. *Pauquette's Rapids, Ottawa River.*

(Attention is directed to the fact that figures 18 and 19 do not belong with the genus CAMARELLA but should have been included within the lines enclosing figures of the following genus, PARASTROPHIA.)

PARASTROPHIA, HALL.

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PARASTROPHIA REVERSA, Billings.

- Fig. 18. Dorsal view of a specimen; showing the fine concentric lineation of the surface.
- Fig. 19. Cardinal view of the exterior of an average example; showing the relative convexity of the valves and the character of their plication.
- Fig. 23. Cardinal view of a specimen which has been transversely sectioned in the umbonal region, the brachial valve being represented below; showing the spondylium of the pedicle-valve supported by its median septum, and the septal plates of the brachial valve resting on the bottom of the shell and supporting the crural apophyses.

Clinton horizon. *Island of Anticosti.*

PARASTROPHIA HEMPLICATA, Hall.

- Figs. 20, 21. Dorsal and front views of an average specimen; showing the elevation of the plicated fold.

Fig. 22. Cardinal view of an internal cast; showing the median septa and spondylia of both valves.

Trenton limestone. *Jacksonburgh, N. Y.*

PARASTROPHIA LATIPLICATA, Hall.

Fig. 24. An internal cast of the brachial valve in which the filling of the spondylium is exposed and the four scars of the adductor impression distinctly retained.

Fig. 25. Cardinal view of the same specimen.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

PARASTROPHIA MULTIPLICATA, Hall.

Fig. 26. Cardinal view of an individual, showing the casts of the spondylia of the two valves, in the brachial valve the lateral walls having rested upon the inner surface of the shell. The muscular scars of the brachial valve are also retained.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

PARASTROPHIA GREENII, Hall.

Fig. 27. Cardinal view of a rather convex internal cast; showing the cavities left by the median septa.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

ANASTROPHIA, HALL.

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ANASTROPHIA VERNEULI, Hall.

Figs. 28, 29. Dorsal and front views of an average specimen with regularly and sharply plicated surface.

Fig. 30. Cardinal view of a large individual; showing the contour and character of surface plication.

Fig. 31. An interior with the septal plates and muscular scars sharply defined; showing also the false foramen produced by the encroachment of the septal cavity or spondylium upon the beak.

Fig. 32. An enlargement of the interior of the umbonal region of conjoined valves, the pedicle-valve being represented below. In the brachial valve the convergent septal plates bear lateral bilobed expansions or flanges, which are the crural apophyses as shown in section, in fig. 33. In the pedicle-valve the walls of the supported spondylium are folded over each other in such a manner as to form a tubular chamber. This appears to be an abnormal character, as it has been observed in this instance only, but it is nevertheless a natural growth without evidence of break or lesion in the walls of the spondylium. $\times 2$.

Lower Helderberg group. *The Helderbergs, N. Y.*

Fig. 35. Cardinal view of an internal cast, represented with the brachial valve above; showing the cavities of the septal and socket plates in the brachial valve, and of the spondylium and its median septum in the pedicle-valve. $\times 2$.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

ANASTROPHIA DEFLEXA, Sowerby.

Fig. 33. Cardinal view of a specimen which has been transversely sectioned in the umbonal region; showing the supported spondylium of the pedicle (lower) valve, and the septal plates of the brachial valve, bearing the crural apophyses.

Wenlock limestone. *Island of Gotland.*

Fig. 34. Profile of a normal adult example; showing the surface plication and the predominant convexity of the brachial valve.

Wenlock limestone. *Wenlock Edge, England.*

LYCOPHORIA, LAHUSEN.

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LYCOPHORIA NUCELLA, Dalman.

Fig. 36. A longitudinal median section of the two valves; showing the thickening of the umbonal region of the brachial valve and the projection of the cardinal process into the umbonal cavity of the pedicle-valve.

Figs. 37, 38. Dorsal and profile views of a finely plicated, orbicular specimen. In fig. 37, the muscular area is faintly outlined through the substance of the brachial valve.

Fig. 39. Cardinal view of specimen transversely sectioned in the umbonal region, the pedicle-valve being above; showing the dental plates and erect, bifurcate cardinal process. $\times 2$.

Lower Silurian. *Near St. Petersburg, Russia.*

PORAMBONITES, PANDER.

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PORAMBONITES AEQUIROSTRIS, Schlotheim.

Figs. 40, 41. Profile and front views of a ventricose shell; showing the relative convexity of the valves and the development of median fold and sinus.

Fig. 42. Cardinal view of a specimen showing the cardinal area on each valve and, by translucence, the double septa of each valve. $\times 2$.

Fig. 43. A portion of the interior of the pedicle-valve; showing cardinal area, delthyrium and teeth.

Lower Silurian. *Russia.*

PLATE 46.

Legend: d. Spondylium. l. Cruralium.
s. Median septum (pedicle-valve). c. Crura.
s'. Median septum (brachial valve).

CONCHIDIUM, LINNÉ.

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CONCHIDIUM UNGUIFORMIS, Ulrich.

Figs. 1, 2. Dorsal and ventral views of the original specimen; showing the form of the shell, the character of its plication, its concentric varices and fine growth-lines. The drawings are slightly restored in the umbonal region of the pedicle-valve.

Niagara group. *Near Louisville, Kentucky.*

CONCHIDIUM DECUSSATUM, Whiteaves.

Fig. 3. Dorsal view of a small example; showing the form and exterior characters of the species.

Niagara dolomites. *Rapids of the Saskatchewan River, British America.*

CONCHIDIUM LITTONI, Hall.

Figs. 4, 5. Dorsal and profile views of an average specimen; showing the abundant plication of the surface and the characteristic breadth of the valves in the umbonal region.

Niagara group. *Hardin county, Tennessee.*

CONCHIDIUM NYSIUS, Hall and Whitfield.

Figs. 6, 7. Dorsal and profile views of a large individual.

Niagara group. *Near Louisville, Kentucky.*

CONCHIDIUM BILOCULARE, Linné.

Fig. 8. A natural longitudinal section of conjoined valves; showing the relation of the spondylium and septal plates.

Fig. 9. A profile of the same specimen; showing the long, concave and smooth cardinal slopes.

Upper Silurian limestone. *Island of Gotland.*

CONCHIDIUM KNIGHTI, Sowerby.

Fig. 10. Dorsal view of an average typical example; showing the contour of the species, conspicuous and incurved umbo of the pedicle-valve, and the complete plication of the surface. (DAVIDSON.)

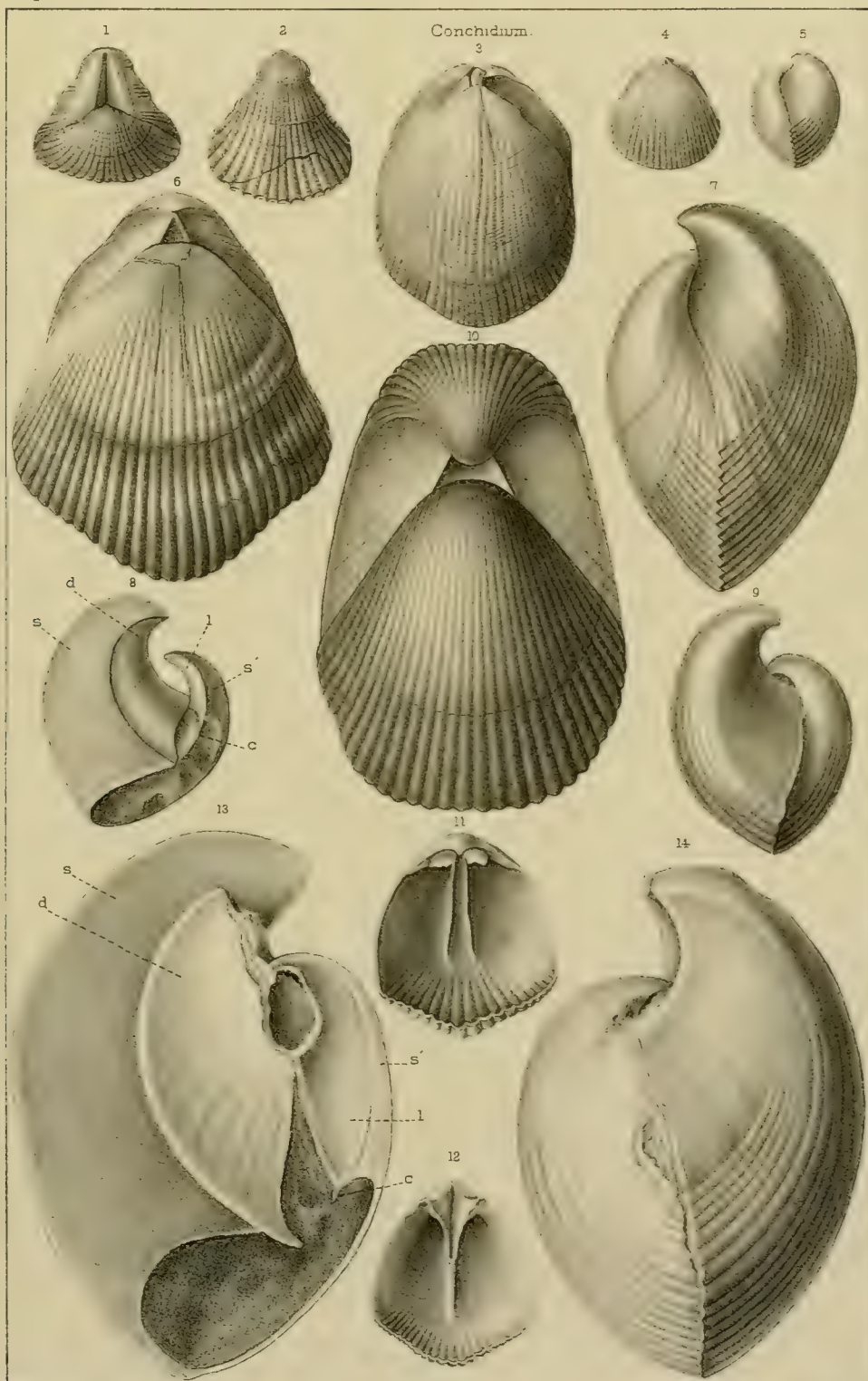
Aymestry limestone. *Aymestry, England.*

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Plating with 1893

James E. Smith, 1893

CONCHIDIUM EXPONENS, Hall.

Figs. 11, 12. The interior of a brachial and pedicle-valves of a strongly costate shell; showing the septa and spondylium.

Niagara group (Halysites bed). *Louisville, Kentucky.*

CONCHIDIUM LAQUEATUM, Conrad (=PENTAMERUS NOBILIS, Emmons).

Fig. 13. Profile view of an internal cast of a rather narrow shell; showing the contour, character of the plication and smooth umbonal slopes.

Fig. 14. Longitudinal section of conjoined valves; showing the extent of the median septum of the pedicle-valve quite to the anterior margin of the valve, its concave anterior edge, the projecting extremity of the spondylium and, in the brachial valve, the relatively short spondylium and septa, and the projection of the crural apophyses.

Niagara dolomites. *Delphi, Indiana.*

PLATE 47.

Legend: d. Spondylium. s'. Median septum (brachial valve).
b. Cruralium. D. Deltidium.
s. Median septum (pedicle-valve). c. Crura.

PENTAMERUS, SOWERBY.

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PENTAMERUS OBLONGUS, SOWERBY.

Figs. 1, 2. Dorsal and ventral views of a subquadrate shell with the lobation of the surface distinctly defined.
Clinton group. *Rochester, N. Y.*

PENTAMERUS OBLONGUS, var. SUBRECTUS, Hall.

Fig. 3. Profile view of a normal mature individual.
Niagara beds. *Castle Grove township, Jones county, Iowa.*

PENTAMERUS OBLONGUS, SOWERBY.

Fig. 4. Dorsal view of a large, elongate, subovate shell, with trilobed surface, broadly shouldered umbones and closely incurved and depressed ventral beak.
Fig. 5. A natural longitudinal section through both valves; showing the comparatively short median septum and septal plates, the projecting spondylium and crural processes.
Clinton group. *Rochester, N. Y.*
Fig. 6. Dorsal view of the umbonal region of an internal cast in chert; showing the cavities left by the septum and septal plates, the deltidium and the lateral divisions of the hinge-plates. $\times 2$.
Niagara beds. *Monmouth, Iowa.*

PENTAMERUS OBLONGUS, var. CYLINDRICUS, Hall and Whitfield.

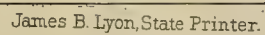
Fig. 7. Dorsal view of the original specimen of this variety; showing the elongate form and a faint trilobation of the exterior.
Niagara group. *Near Louisville, Kentucky.*

PENTAMERUS PERGIBBOSUS, Hall and Whitfield.

Fig. 8. Profile of a small and gibbous internal cast.
Niagara dolomites. *Near Milwaukee, Wisconsin.*
Fig. 9. Cardinal view of an internal cast of a small shell, which shows with much distinctness the position and form of the deltidium.
Chert of the Niagara group. *Wisconsin.*

Generic Illustrations.

Plate 47.



CAPELLINIA, HALL.

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CAPELLINIA MIRA, Hall.

Figs. 10, 11. Ventral and cardinal views of an average specimen; showing the predominant convexity of the brachial valve, the smooth surface and the position and extent of the internal plates.

Fig. 12. Profile view of a normal individual; showing the relations of the valves.

Niagara dolomites. *Near Milwaukee, Wisconsin.*

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PLATE 48.

- Legend: d. Spondylium. VA. Cardinal area (pedicle-valve.)
 s. Median septum (pedicle- dp. Deltaria (remnants of deltidium?).
 valve). l. Cruralium.
 s'. Median septum (brachial
 valve).

BARRANDELLA, HALL.

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BARRANDELLA LINGUIFERA, Sowerby.

- Figs. 1, 2. Dorsal and profile views of a normal individual; showing the character of the exterior and the well-defined median fold on the brachial valve.
Fig. 3. A longitudinal median section of the valves; showing the small spondylium and extremely short median septum of the pedicle-valve, and one of the septal plates of the brachial valve. (DAVIDSON.)
Wenlock limestone. *Dudley, England.*

BARRANDELLA VENTRICOSA, Hall.

- Figs. 4, 5. Dorsal and front views of a typical example; showing the fold upon the brachial valve, its faint plication, and the cavities of the median septa.
Niagara dolomites. *Waukesha, Wisconsin.*

PENTAMERELLA, HALL.

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PENTAMERELLA ARATA, Conrad.

- Figs. 6-8. Dorsal, profile and anterior views of a characteristic individual; showing the irregular dichotomous plication of the surface and the development of fold and sinus on brachial and pedicle-valves respectively.
Schoharie group. *Albany county, N. Y.*
Fig. 9. The interior of an incomplete pedicle-valve; showing the form of the spondylium.
Fig. 10. An interior of the brachial valve; showing the completed spondylium (cruralium) resting upon the bottom of the valve.
Corniferous limestone. *Waterloo, N. Y.*

PENTAMERELLA DUBIA, Hall.

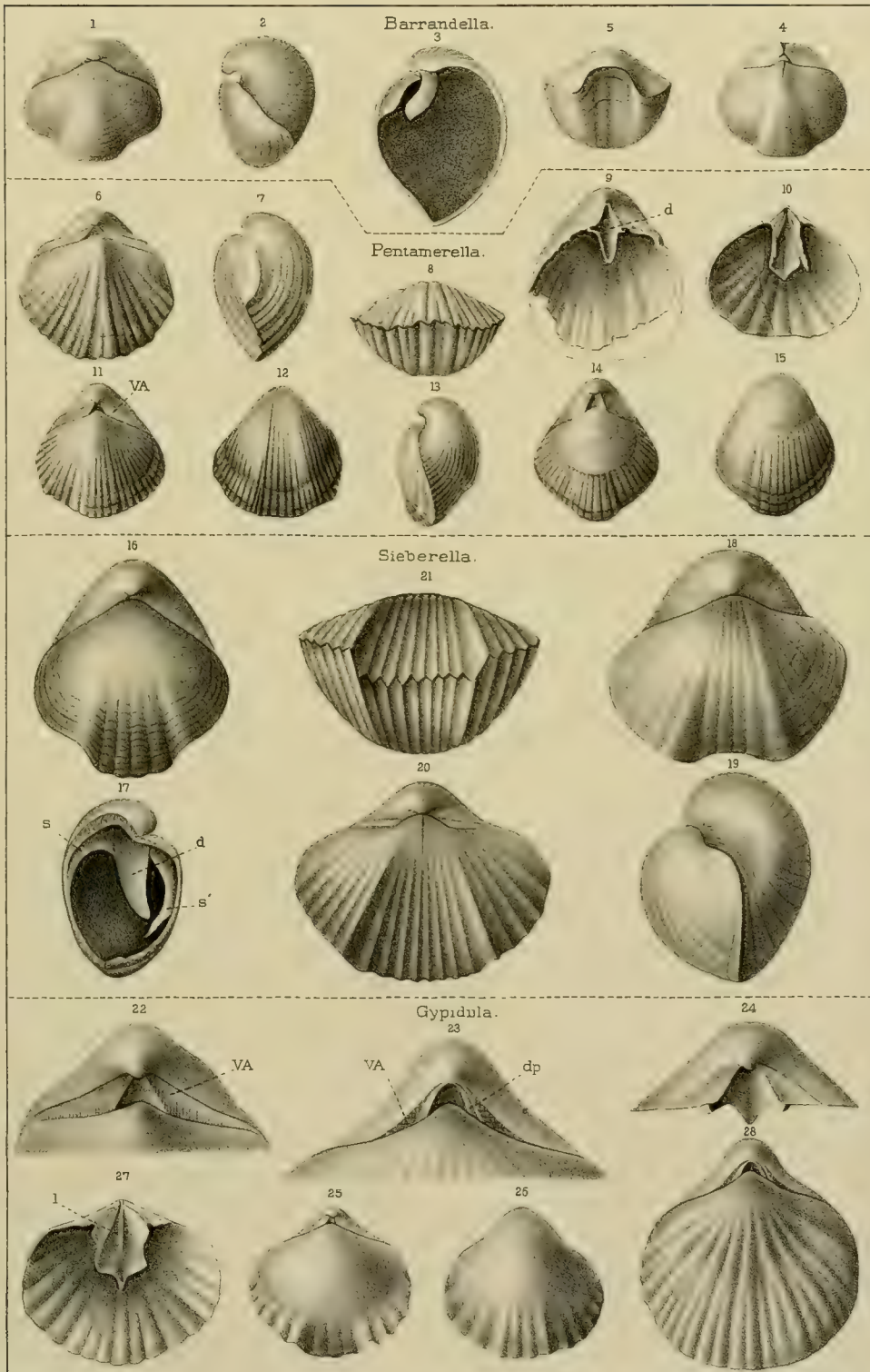
- Figs. 11-13. Dorsal, ventral and profile views of an example having the cardinal area obscurely defined and the surface covered with fine, regular plications.
Figs. 14, 15. Dorsal and profile views of a characteristic specimen from which the shell is partially exfoliated on the pedicle-valve.
Hamilton beds. *Littleton, Iowa.*

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SIEBERELLA, C̄HLERT.

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SIEBERELLA GALEATA, Dalman.

Fig. 16. Dorsal view of an elongate shell with plicated sinus and smooth lateral slopes.

Fig. 17. A view of the interior of conjoined valves; showing the spondylium and its supporting septum, one of the septal plates and its crural process.

Lower Helderberg group. *The Helderbergs, N. Y.*

Figs. 18, 19. Dorsal and profile views of a well-developed example, with transverse form, highly convex valves, typically developed plicated sinus and obscurely plicated lateral slopes.

Wenlock limestone. *Dudley, England.*

SIEBERELLA SIEBERI, von Buch.

Figs. 20, 21. Dorsal and front views of a typical mature example; showing the strong plication of the surface and the sinus in the brachial valve.

Lower Devonian (Etage F₂). *Konieprus, Bohemia.* (BAR-
RANDE.)

GYPIDULA, HALL.

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GYPIDULA COMIS, Owen.

Fig. 22. Dorsal view of the umbonal region enlarged; showing the longitudinally striated and sharply delimited cardinal area.

Upper Devonian. *Independence, Iowa.*

Figs. 25, 26. Dorsal and ventral views of a normal example; showing the marginal plication of the valves, their convexity and the development of median fold and sinus on pedicle- and brachial valves respectively.

Upper Devonian. *Lime Creek, Iowa.*

GYPIDULA ROMINGERI, Hall.

Fig. 23. Dorsal view of the umbonal region of the specimen represented in fig. 28, enlarged to show the sharply defined cardinal area and the deltidial plates or remnants of the deltidium. $\times 2$.

Fig. 24. Cardinal view of a pedicle-valve; showing a well-defined cardinal area, the teeth and the form of the spondylium.

Fig. 27. The interior of a brachial valve; showing the curved wall of the sessile spondylium.

Fig. 28. Dorsal view of an individual of average size, with an unusually flat brachial valve; showing the cardinal area, plates of the deltidium and coarse, irregularly duplicate plication of the surface.

Hamilton group. *Near Alpena, Michigan.*

PLATE 49.

Legend: VA. Cardinal area (pedicle-valve). t. Teeth.
d. Spondylium. hp. Hinge-plate.
s. Median septum (pedicle-valve). o. Cast of visceral foramen.
s'. Septa (brachial valve.)

STRICKLANDINIA, BILLINGS.

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STRICKLANDINIA CASTELLANA, White.

Figs. 1-3, 5. Dorsal, ventral, profile and cardinal views of a characteristic specimen; showing the nearly equiconvex valves, the strong, irregularly fasciculate or duplicate plication, and, in fig. 5, the cavities left by the spondylium and low median septum of the pedicle-valve.
Niagara group. *Jones county, Iowa.*

STICKLANDINIA, sp.

Fig. 4. An internal cast of the pedicle-valve; showing the well-defined cardinal area.
Niagara group. *Hamilton, Ontario.*

STRICKLANDINIA ANTICOSTIENSIS, Billings.

Fig. 6. A view looking into the umbonal cavity of the pedicle-valve; showing the spondylium and its supporting septum.
Fig. 7. The interior of a pedicle-valve, distorted by natural growth, and showing a sharply-defined cardinal area, delthyrium and spondylium.
Anticosti group. Anticosti.

AMPHIGENIA, HALL and WHITFIELD.

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AMPHIGENIA ELONGATA, Vanuxem.

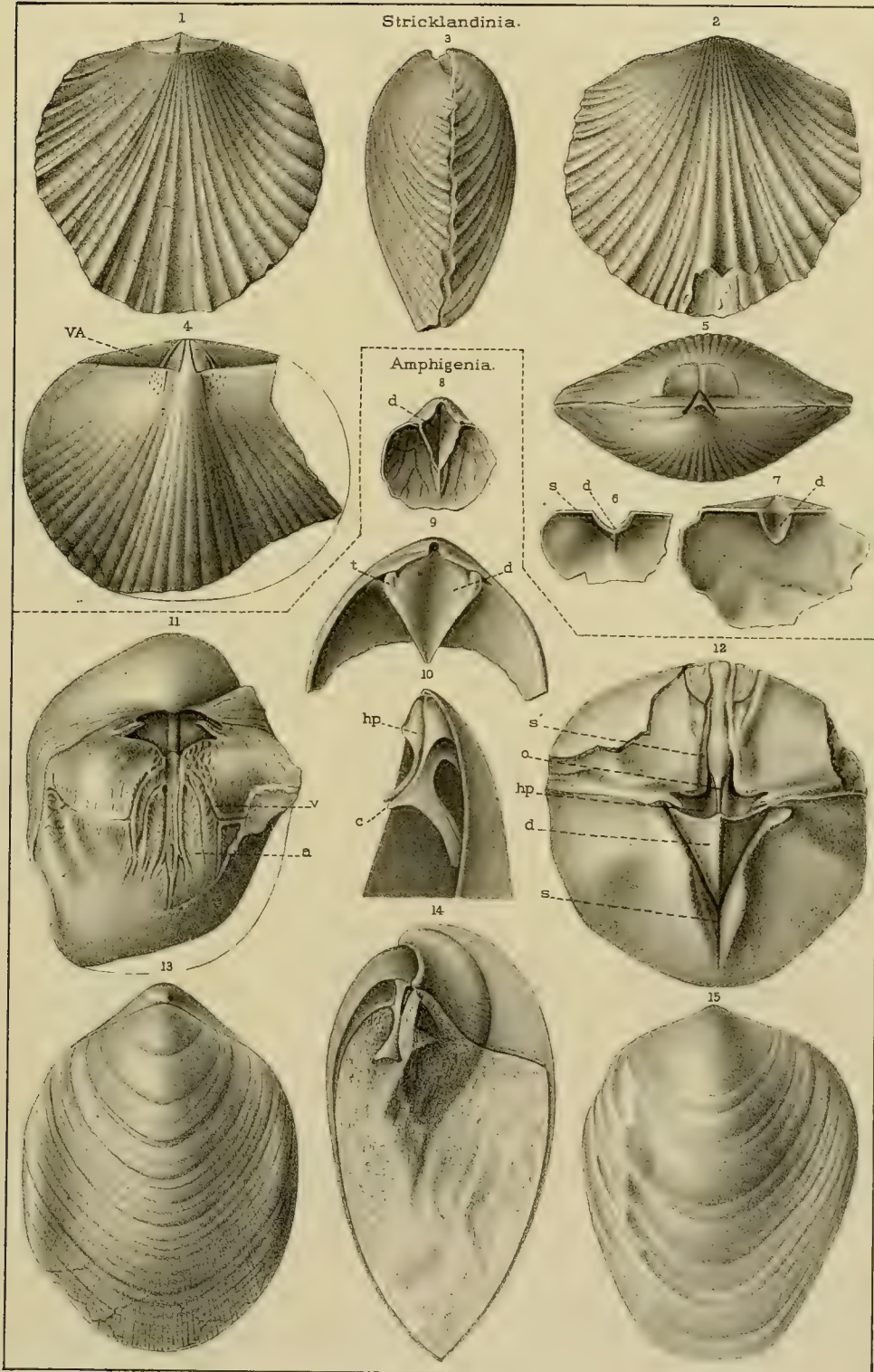
Fig. 8. The interior of the umbonal portion of a pedicle-valve; showing vascular sinuses on the surface of the valve beneath the spondylium.
Corniferous limestone. From the drift of southern Michigan.
Fig. 9. The interior of the umbonal portion of the pedicle-valve; showing the teeth and the entire spondylium.
Corniferous limestone. Le Roy, N. Y.
Fig. 10. Profile view of a portion of the brachial valve somewhat enlarged to show the direction and extent of the crura, jugal apophyses and crural plates.
Fig. 11. Dorsal view of a partial cast; showing the muscular impressions and vascular sinuses of the brachial valve, and the cavity left by the medially divided hinge-plate.
Corniferous limestone. Clarence, N. Y.

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Philip Ast lith.

James B. Lyon, State Printer.

Fig. 12. Cardinal view of an internal cast; showing the filling of the spondylium and of the visceral foramen, and the cavities left by the median septum and hinge-plate.

Fig. 13. Dorsal view of an individual of medium size with regularly elliptical form and finely striated surface.

Corniferous limestone. *Western N. Y.*

Fig. 14. Median longitudinal section of both valves; showing the degree of development of the spondylium, median septum, and septal plates; also the great thickness of the shell in the umbonal region of the brachial valve and the length of the crura, with their convex terminal expansion.

Corniferous limestone. *Le Roy, N. Y.*

Fig. 15. The exterior of a brachial valve having the characteristic subovate outline.

Corniferous limestone. *Cayuga, Ontario.*

PLATE 50.

- | | |
|------------------------------|------------------------------|
| Legend: dp. Deltaria. | v. Vascular sinuses. |
| d. Dental plates. | a. Posterior adductor scars. |
| hp. Hinge-plate. | á. Anterior adductor scars. |
| o. Cast of visceral foramen. | |

RENSSELÆRIA, HALL.

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RENSSELÆRIA MUTABILIS, Hall.

- Figs. 1, 2. Dorsal and profile views of a rather large and somewhat elongate shell.
- Fig. 3. The loop enlarged to show its form in more detail; the elongate triangular expansion formed by the union of the descending lamellæ, and the median ridge along the line of coalescence of these parts, produced upwardly and posteriorly into a free extremity.
Lower Helderberg group. *Becraft's Mountain, Columbia Co., N. Y.*

RENSSELÆRIA MARYLANDICA, Hall.

- Fig. 4. Enlarged view of the cardinal portion of the pedicle-valve; showing the foramen and deltidial plates.
- Fig. 5. The interior of the umbonal portion of a brachial valve of an old shell in which the hinge-plate is much thickened. The specimen is projected backward to show the inner extremity of the visceral canal, the outer opening being visible at the apex of the plate. This canal is, however, closed by testaceous deposit, and the median division of the plate on its upper surface largely obscured from the same cause.
- Fig. 6. The interior of the umbonal portion of the pedicle-valve; showing the dental plates and muscular impression.
- Fig. 7. Dorsal view of a typical exterior; showing the fine surface plication and the oval outline of the valves.
- Fig. 8. Longitudinal section of the valves; showing the loop in profile, its anterior extension and the elevation of the crural apophyses; also the depth of the dental plates in the pedicle-valve and the umbonal thickening of the shell.
- Fig. 9. The interior of the brachial valve; showing the medially divided hinge-plate and the loop with its long, acutely triangular anterior plate and median ridge with its short and free posterior extension.
Oriskany sandstone. Cumberland, Maryland.

RENSSELÆRIA OVOIDES, Eaton.

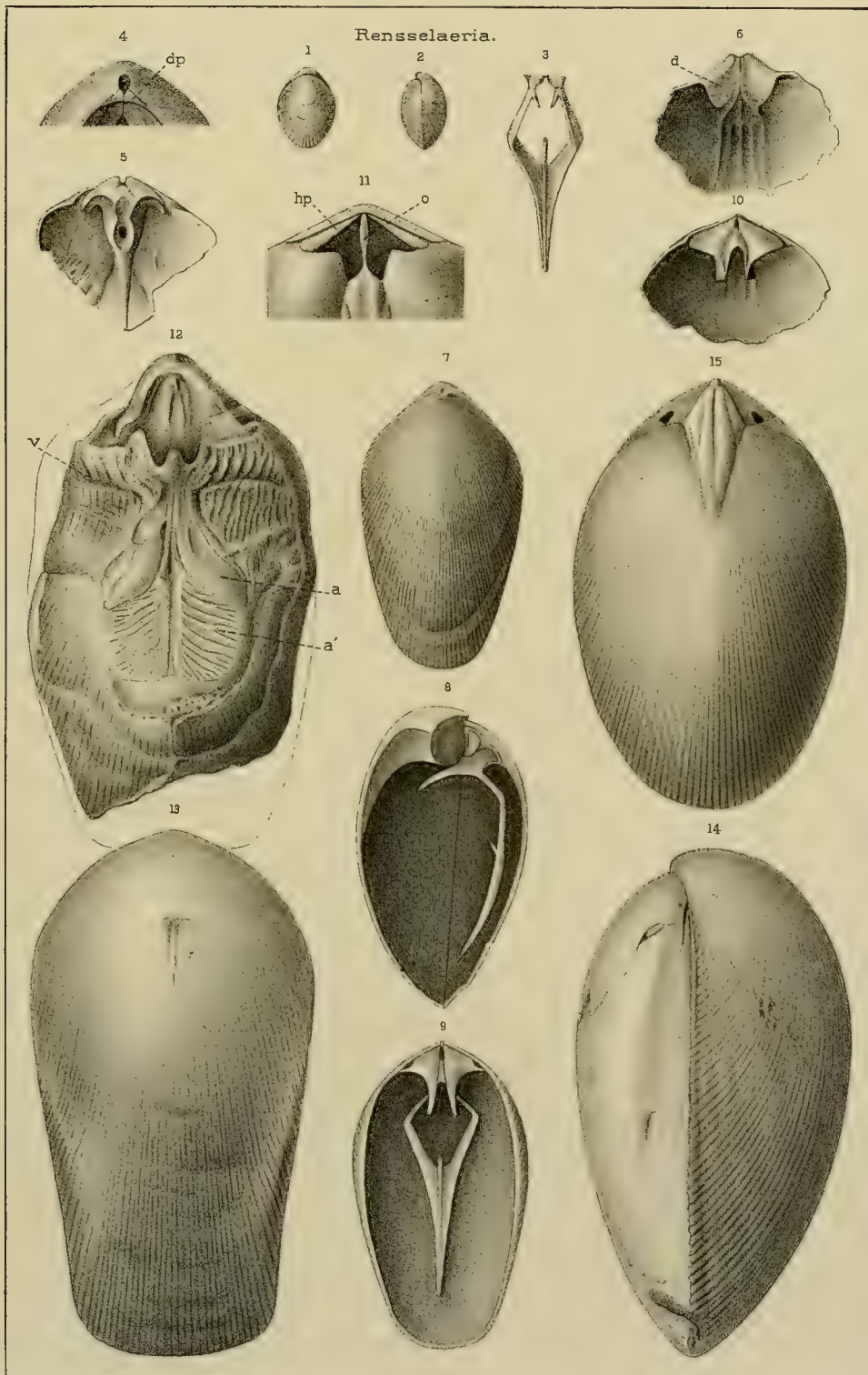
- Fig. 10. The hinge-plate enlarged; showing its form, the opening of the visceral canal, the highly developed crural plates; also the elongate dental sockets and outer socket walls. $\times 2$.

BRACHIOPODA.

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Philip Ast lith.

James B Lyon, State Printer.

Fig. 11. A cast of the hinge-plate; showing the unbroken filling of the visceral canal.

Oriskany sandstone. *The Helderbergs, N. Y.*

RENSELÆRIA OVOIDES, Eaton.

Fig. 12. An interior cast of the brachial valve; showing the cavity of the hinge-plate, the branching vascular sinuses in the umbonal region and the anterior and posterior divisions of the adductor muscular impression, the surface of the posterior scars being strongly marked with ramifying lines. The structure and arrangement of all of these parts is strikingly similar to that occurring in AMPHIGENIA.

Oriskany sandstone. *Schoharie, N. Y.*

Fig. 13. The exterior of a pedicle-valve, having the characteristic inflexion of the lateral margins anteriorly, and showing the fine surface plication.

Fig. 14. Profile of conjoined valves; showing the usual convexity of the species. The shell of the brachial valve has been exfoliated, losing its surface plication.

Oriskany sandstone. *The Helderbergs, N. Y.*

RENSELÆRIA OVULUM, Hall.

Fig. 15. An internal cast of the pedicle-valve; showing the filling of the deep muscular cavity and its division by the diductor and adductor scars, and the cavities left by the teeth. This species differs from the foregoing in its persistently greater size, much more convex valves, and coarser plication of the surface. It is a more orbicular and more regularly convex shell than *R. ovoides*.

Oriskany sandstone. *Cayuga, Ontario.*

PLATE 51.

Legend: c. Crural bases.

á. Anterior adductor scars.

a. Posterior adductor scars.

SUBGENUS BEACHIA, HALL.

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BEACHIA SUESSANA, Hall.

Figs. 1, 2, 3. Ventral, profile and dorsal views of a typical example; showing the outline, contour and plication of the valves and their lateral marginal inflexion.

Fig. 4. Front view of conjoined valves; showing the fine plication of the surface and the inflexion of the lateral margins.

Fig. 5. View of the hinge-plate. $\times 2$.

Fig. 6. The interior of a brachial valve; showing the hinge-plate, medially depressed and perforated at its apex by the visceral foramen, the dental sockets, and the form of the loop with the median rod-like process extending backward and upward from the anterior plate.

Fig. 7. Median longitudinal section of conjoined valves; showing in profile the loop with its long, erect crural apophyses, the elevation and direction of the median process extending backward from the anterior plate.

Oriskany sandstone. *Cumberland, Maryland.*

MEGALANTERIS, SUESS.

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MEGALANTERIS OVALIS, Hall.

Fig. 8. An internal cast of the pedicle-valve; showing the filling of the deep scar of the diductor muscles, enclosing the small subcordate adductor scar, with traces of vascular sinuses and genital markings.

Fig. 9. A similar view of another specimen to which a portion of the pedicle-valve adheres; showing the cavity of the hinge-plate and the division of the muscular area into anterior and posterior scars.

Fig. 10. The dorsal side of an internal cast; showing the deep impression of the prominent hinge-plate and cardinal process, and the adductor muscular scars.

Oriskany sandstone. *Schoharie, N. Y.*

Fig. 11. Interior view of the cardinal portion of the brachial valve enlarged; showing the hinge-plate and the stout, erect, bilobed, and deeply grooved cardinal process; the broad crural bases and a portion of the muscular impression. $\times 2$.

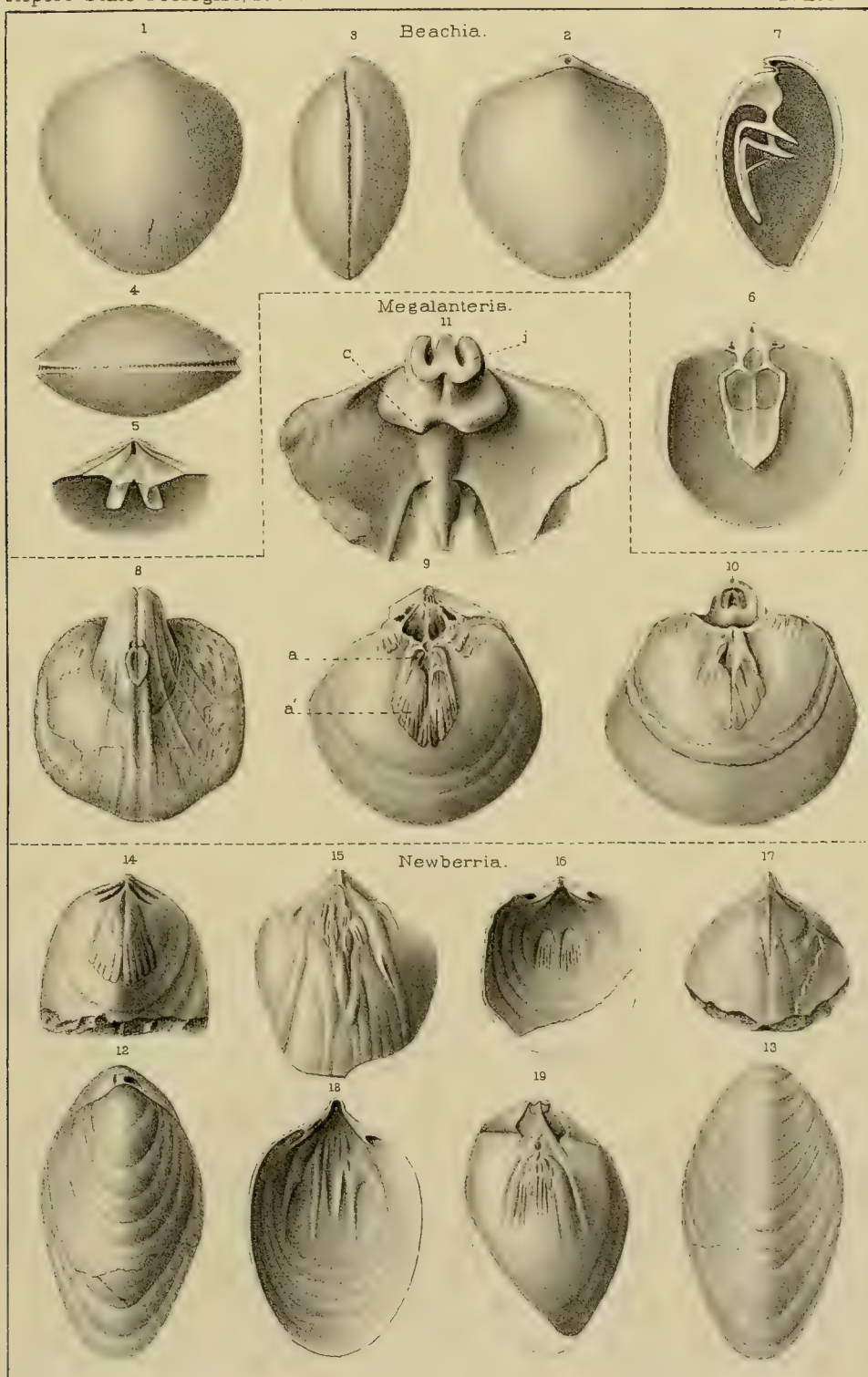
Oriskany sandstone. *Albany county, N. Y.*

BRACHIOPODA.

Generic Illustrations.

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Plate 51.



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NEWBERRIA, HALL.

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NEWBERRIA JOHANNIS, Hall.

- Figs. 12, 13. Opposite sides of a large and characteristic specimen; showing the elongate-oval form and the decided median angulation of the valves.
- Fig. 14. An internal cast of the upper portion of the brachial valve; showing the impression of the divided hinge-plate and the adductor scar.
- Fig. 17. An internal cast of a similar portion of the pedicle-valve.
Hamilton group. *Waterloo, Iowa.*

NEWBERRIA CLAYPOLII, Hall.

- Fig. 15. An internal cast of a portion of the pedicle-valve; showing the divergent impressions of the dental lamellæ, the irregularly divided scar of the adductor muscles, the narrow anterior adductor and strong vascular impressions.
- Fig. 16. A portion of the interior of the brachial valve, drawn from a gutta-percha impression of a natural internal cast; showing the division of the hinge-plate, and the striated adductor impressions.
- Fig. 18. The interior of a pedicle-valve, from a gutta-percha impression; showing an open delthyrium, the divergent dental plates, the muscular and vascular impressions.
- Fig. 19. An internal cast of the pedicle-valve; showing the impression of the apical cup-shaped depression of the pedicle-valve. By the removal of the filling of the dental sockets, the cardinal slope, is made to appear unusually large and flat.
Sandstones of the Hamilton group. *Perry county, Pennsylvania.*

PLATE 52.

Legend:

D. Deltaria.	a. Adductor scars.
c. Crural bases.	v. Vascular sinuses.
r. Diductor scars.	

CENTRONELLA, BILLINGS.

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CENTRONELLA GLANS-FAGEA, Billings.

Figs. 1, 2, 3. Dorsal, ventral and profile views of a small specimen; showing the convexo-concave contour. $\times 3$.

Fig. 4. The interior of the umbonal portion of the brachial valve; showing the thickened divisions of the hinge-plate and the adductor scars.
 $\times 3$.

Corniferous limestone. *Drift near Ann Arbor, Michigan.*

Fig. 5. An internal cast; showing the impression of the hinge-plate, dental sockets and muscular scars of the brachial valve. $\times 2$.

Schoharie grit. *Albany county, N. Y.*

Figs. 6, 7. Two views of the loop. $\times 5$.

Corniferous limestone. *Western New York.*

TRIGERIA, BAYLE.

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TRIGERIA LEPIDA, Hall.

Figs. 8, 9, 10. Dorsal, profile and ventral views of a normal example. $\times 2$.
Hamilton group. *Canandaigua Lake, N. Y.*

ORISKANIA, HALL.

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ORISKANIA NAVICELLA, Hall.

Figs. 11, 12, 13. Dorsal, profile and ventral views of an average example.
Oriskany sandstone. *Rondout, N. Y.*

ROMINGERINA, HALL.

Page 855.

ROMINGERINA JULIA, A. Winchell.

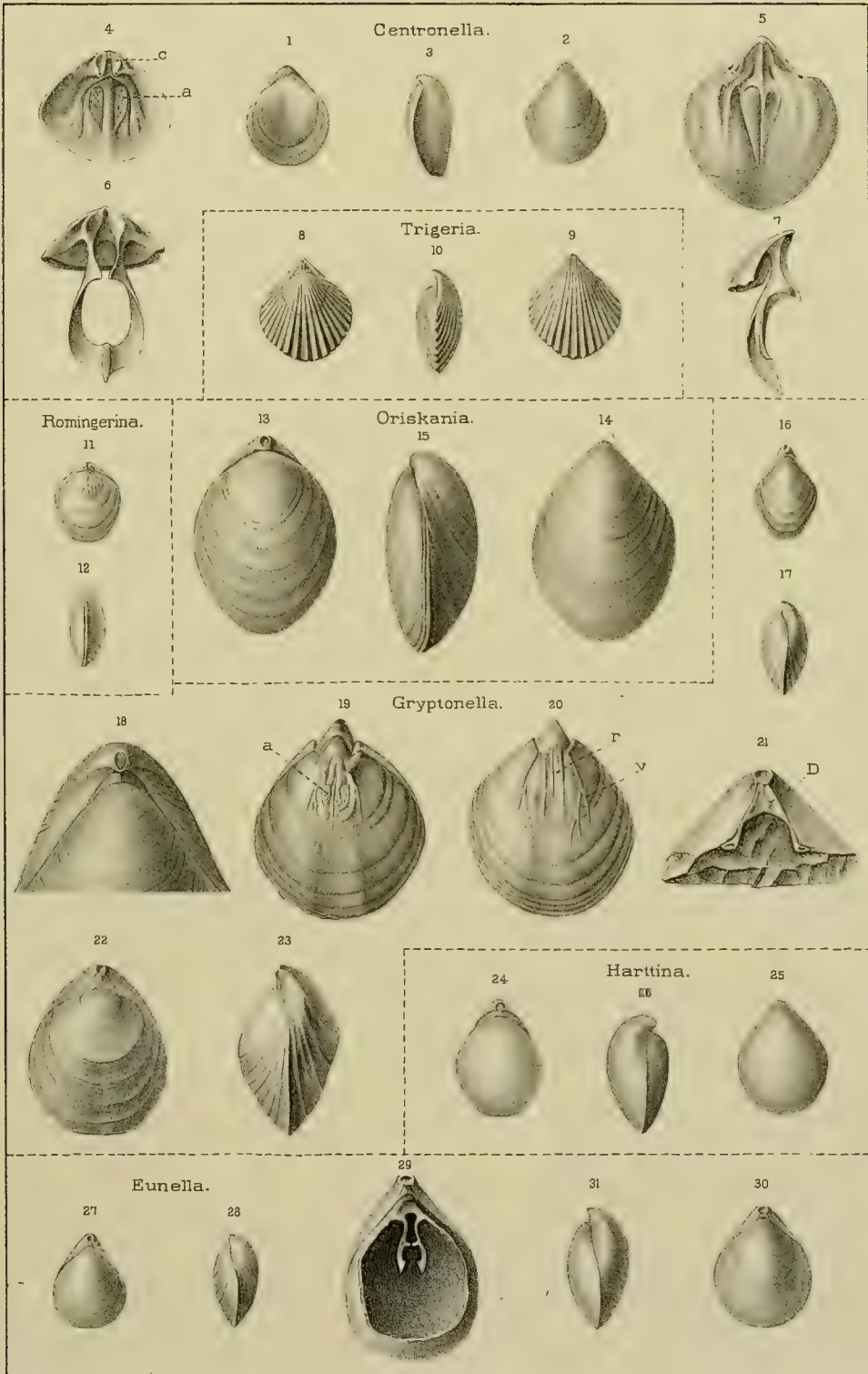
Figs. 14, 15. Dorsal and profile views of an internal cast. $\times 2$.
Marshall group. *Pointe aux Barques, Michigan.*

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Plate 52.



Philip Ast lith.

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CRYPTONELLA, HALL.

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CRYPTONELLA EXIMIA, Hall.

Fig. 16. An enlargement of the umbonal portion of the valves; showing the deltaria. $\times 3$.

Lower Helderberg group. *The Helderbergs, N. Y.*

CRYPTONELLA RECTIROSTRA, Hall.

Figs. 17, 18. Dorsal and profile views of a small example.

Hamilton shales. *Canandaigua Lake, N. Y.*

CRYPTONELLA PLANIROSTRA, HALL.

Figs. 19, 20. Dorsal and ventral views of an internal cast; showing the muscular impressions and vascular sinuses.

Hamilton group. *Hardy county, Virginia.*

Fig. 21. An enlargement of the cardinal portion of the pedicle-valve; showing the foramen, deltidial plates and teeth.

Hamilton group. *Moscow, N. Y.*

Figs. 22, 23. Dorsal and profile views of a normal adult.

Hamilton group. *Western New York.*

EUNELLA, HALL.

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EUNELLA SIMULATOR, Hall.

Fig. 24. Dorsal view of a specimen which has been cut to show the loop, the recurved branch of which is not retained. $\times 2$.

Hamilton group. *Theford, Ontario.*

21, 22

EUNELLA SULLIVANTI, Hall.

Figs. 25, 26. Dorsal and profile views of the original specimen.

Corniferous limestone. *Columbus, Ohio.*

10, 31

EUNELLA LINCKLAENI, Hall.

Figs. 27, 28. Dorsal and profile views of a mature shell.

Hamilton group. *Canandaigua Lake, N. Y.*

HARTTINA, HALL.

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HARTTINA ANNA, Hartt.

Figs. 29, 30, 31. Dorsal, profile and ventral views of a well-preserved example; showing the subplano-convex contour of the valves.

Carboniferous limestone. *Windsor, Nova Scotia.*

PLATE 53.

Legend: F. Foramen. m. Muscular platform.
p. Pedicle-groove. fc. Foraminal sheath.
d. Dental plates. D. Deltaria.

BEECHERIA, HALL.

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BEECHERIA DAVIDSONI, Hall.

Fig. 1. The internal cardinal structure exposed by the removal of a portion of the pedicle-valve; showing the absence of dental plates in this valve and the structure of the loop. $\times 3$.

Figs. 2, 3. Dorsal and profile views of an average example.
Carboniferous limestone. *Windsor, Nova Scotia*.

CRANÆNA, HALL.

Page 865.

CRANÆNA ROMINGERI, Hall.

Figs. 4, 5, 6. Dorsal, ventral and profile views of a typical example. $\times 2$.
Hamilton group. *Thunder Bay, Michigan*.

CRANÆNA IOWENIS, Calvin.

Figs. 7, 8. Dorsal and profile views of a normal individual.
Hamilton group. *Rockford, Iowa*.

Fig. 9. A preparation showing the structure of the loop, the ascending branches being partially retained. $\times 2$.
Hamilton group. *Fayette, Iowa*.

DIELASMA, KING.

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DIELASMA TURGIDA, Hall.

Fig. 10. Dorsal view of a specimen having a single plication in the sinus of the pedicle-valve. $\times 1\frac{1}{2}$.

Fig. 11. Dorsal view of an example with broad median sinus. $\times 2$.
Chester limestone. *Spencer county, Indiana*.

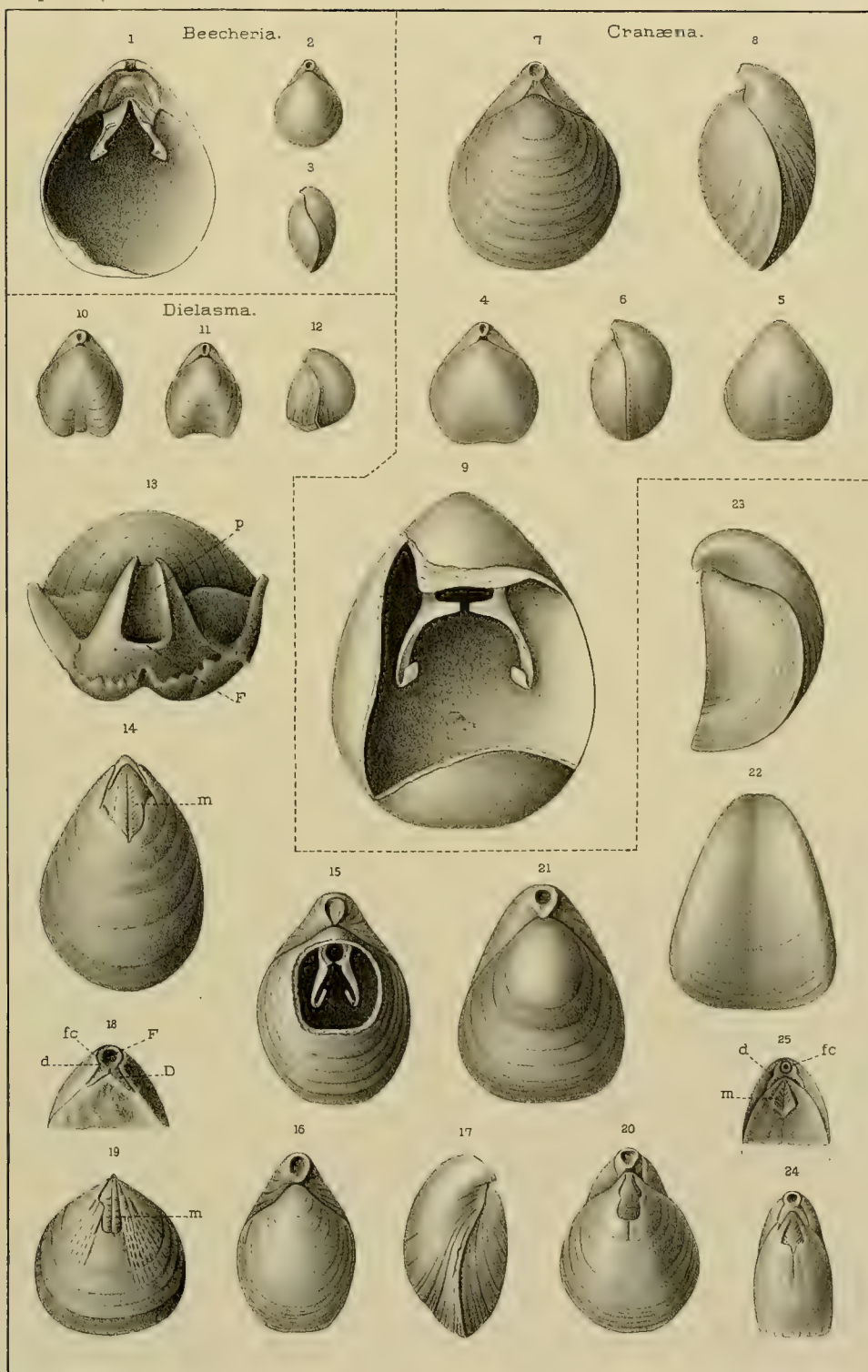
Fig. 12. Profile of an old shell with highly ventricose valves.
St. Louis group. *Washington county, Indiana*.

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Philip Ast lith.

James B. Lyon, State Printer.

DIELASMA, sp. ?

Fig. 13. Cardinal view of a specimen enlarged to show the oblique opening of the pedicle-passage and its cross-striated surface. $\times 3$.

Fig. 14. An internal cast of a brachial valve; showing the form of the muscular platform. $\times 3$.

Chester limestone. *Caldwell county, Kentucky.*

DIELASMA FORMOSA, Hall.

Fig. 15. Dorsal view of a specimen, cut to expose the loop.

Figs. 16, 17. Dorsal and profile views of a characteristic and somewhat gibbous example.

St. Louis group. *Washington county, Indiana.*

Fig. 18. A cast of the cardinal portion of the pedicle-valve, enlarged to show the cavity left by the enfolded margin of the pedicle-passage, the dental lamellæ and deltaria. $\times 2$.

Fig. 19. An internal cast of the brachial valve; showing the impression of the muscular platform and the genital markings.

St. Louis group. *Washington county, Indiana.*

DIELASMA ROWLEYI, Worthen.

Fig. 20. Dorsal view of an internal cast; showing the impression of the muscular platform of the brachial valve.

Choteau limestone. *Graydon Springs, Missouri.*

DIELASMA BOVIDENS, Morton.

Figs. 21, 22, 23. Dorsal, profile and ventral views of a large and characteristic example; showing the curvature of the valves and the oblique for-
aminal aperture.

Carboniferous limestone. *Harrison county, Missouri.*

Fig. 24. Dorsal view of an internal cast of a narrow shell, in which the impression of the muscular platform of the brachial valve is sharply defined.

Fig. 25. The reverse of the upper portion of the same specimen; showing the introverted lamella about the foramen, a portion of the dental plates and the form of the muscular platform.

Carboniferous limestone. *Locality ?*

PLATE 54.

Legend: ch. Chilidium.
j. Cardinal process.

b. Dental sockets.
r. Subrostral plate.

TROPIDOLEPTUS, HALL.

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TROPIDOLEPTUS OCCIDENS, Hall.

Figs. 1, 2. Dorsal and ventral views of the original specimens of this species.
Hamilton group. *Iowa City, Iowa.*

TROPIDOLEPTUS CARINATUS, Conrad.

Fig. 3. The pedicle-valve of a very young shell with acuminate cardinal extremities and coarse, simple and sharp plication. $\times 3$.

Hamilton group. *Canandaigua Lake, N. Y.*

Fig. 4. An enlargement of an interior layer of the shell, showing the punctæ.

Figs. 5, 6, 7. Ventral, profile and dorsal views of an average example; showing the exterior characters.

Fig. 8. Cardinal view of the umbonal portion of the valves; showing the open delthyrium and the great development of the chilidium. $\times 3$.

Fig. 9. The interior of a brachial valve; showing the cardinal process, crenulated dental sockets and median septum.

Fig. 10. An internal cast of a brachial valve; showing the impression of the cardinal process and crenulated dental sockets.

Fig. 11. The interior of a pedicle-valve; showing the cardinal area, open delthyrium and the prominent crenulated teeth.

Hamilton group. *From various localities in the argillaceous and arenaceous shales of Central and Western New York.*

EICHWALDIA, BILLINGS.

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EICHWALDIA RETICULATA, Hall.

Fig. 12. Dorsal view of a very young example. $\times 10$. (After BEECHER and CLARKE.)

Fig. 13. Dorsal view of an average mature specimen. $\times 2$.

Fig. 14. The interior of the umbonal portion of the pedicle-valve; showing the subrostral plate. $\times 2$.

Fig. 15. The interior of a brachial valve; showing the cardinal process and the marginal grooves for the reception of the ridges of the opposite valve. $\times 2$.

Fig. 16. The interior of the pedicle-valve; showing the open delthyrium and the linear ridges on the lateral margins. $\times 2$.

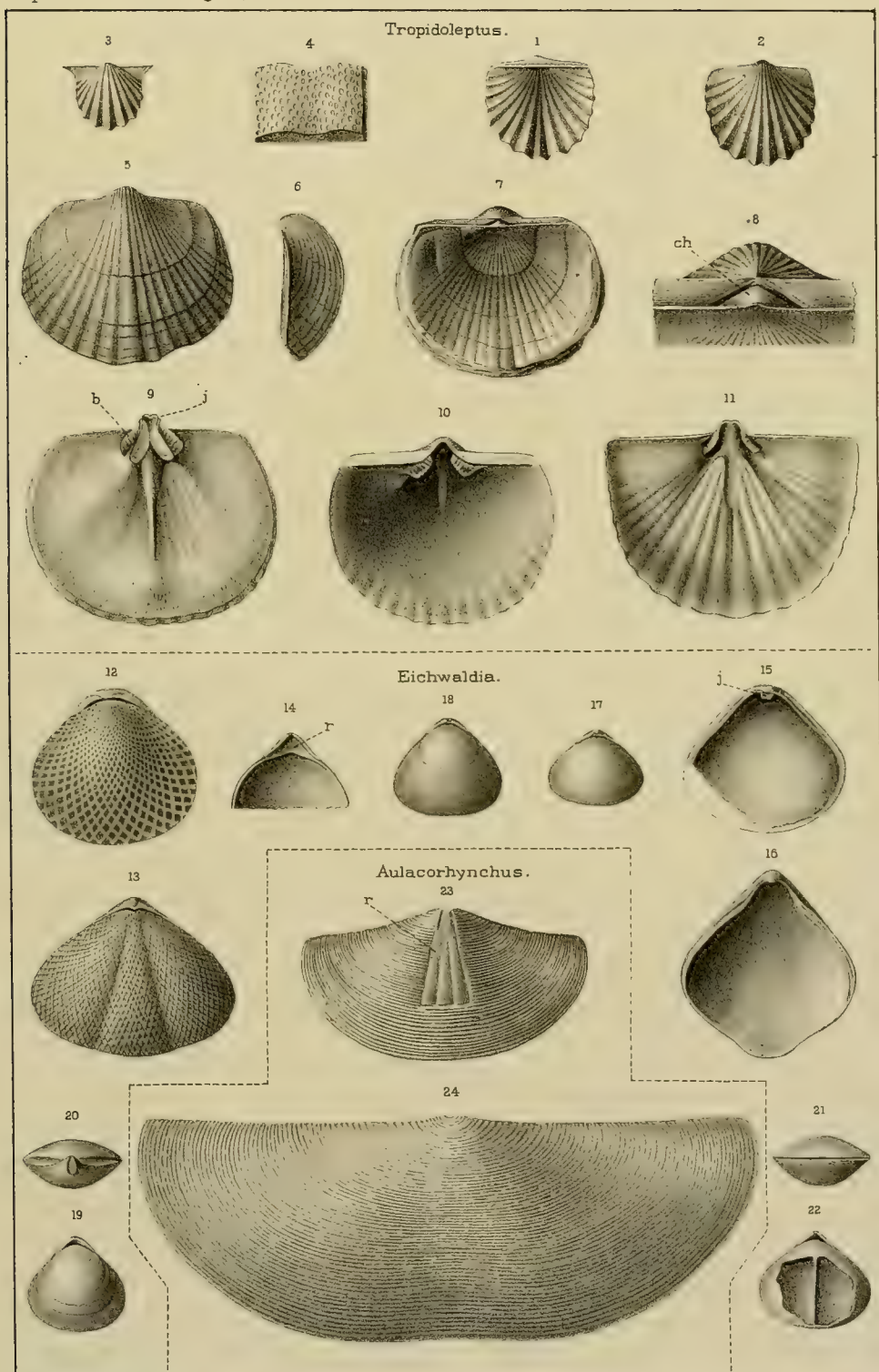
Niagara group. *Waldron, Indiana.*

BRACHIOPODA.

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Philip Ast lith.

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EICHWALDIA CONCINNA, Hall.

Fig. 17. Dorsal view of the original specimen.
Niagara group. *Perry county, Tennessee.*

EICHWALDIA GIBBOSA, Hall.

Fig. 18. Dorsal view of the original specimen.
Niagara group. *Perry county, Tennessee.*

EICHWALDIA SUBTRIGONALIS, Billings.

Figs. 19, 20, 21. Dorsal, cardinal, and front views; showing the smooth surface of the valves and the "bare-spot" or pedicle-aperture.

Fig. 22. Dorsal view of a specimen in which the brachial valve is so broken as to expose its median septum.
Black River limestone. *Pauquette's Rapids, Canada.*

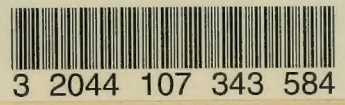
AULACORHYNCHUS, DITTMAR.

Page 904.

AULACORHYNCHUS MILLEPUNCTATUS, Meek and Worthen.

Fig. 23. The exterior of a pedicle-valve from which a portion of the shell has been exfoliated; showing the inner surface of the triangular platform.

Fig. 24. A very large brachial valve; showing the outline and surface characters.
Coal measures. *Crooked Creek, Illinois.*



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